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ABSTRACT

This teacher's guide is designed to aid teachers in leading students through a module on airframe structures and nonmetallic structural repairs. The module contains four units that cover the following topics: (1) identifying aerodynamic and construction characteristics of aircraft structures; (2) inspecting wooden structures; (3) inspecting and repairing bonded structures; and (4) inspecting and repairing transparent plastic materials. Each unit follows a standardized format that consists of the following components: introduction and module objective, specific objectives, instructor's implementation guide, technical information supplements, transparency masters, workbook supplements, answers to workbook supplements, project guides, theory test, and answers to theory test. A course test with answer key completes the package. (KC)

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AVIATION MAINTENANCE TECHNOLOGY

AIRFRAME

A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

INSTRUCTOR MATERIAL

CE051567

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MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

AIRFRAME

A201 AIRCRAFT STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

IDENTIFY AERODYNAMIC AND CONSTRUCTION CHARACTERISTICS OF AIRCRAFT STRUCTURES

A201-A

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
IDENTIFY AERODYNAMIC AND CONSTRUCTION CHARACTERISTICS OF AIRCRAFT STRUCTURES
A201-A

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B. Specific Objectives

C. Instructor's Module Implementation Guide

D. Technical Information Supplement #1 — Terms and Definitions

E. Transparency Masters

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2. TM #2 — Dihedral Angle
3. TM #3 — Wooden Spars
4. TM #4 — Metal Spars
5. TM #5 — Wooden Wing Internal Structure
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7. TM #7 — Empennage Construction Features
8. TM #8 — Monocoque Type of Construction
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10. TM #10 — Truss Fuselage Construction
11. TM #11 — Primary Aircraft Control Surfaces
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   4. Workbook Supplement #4 — Label Aircraft Control Surfaces, Auxiliary Surfaces, and Auxiliary Devices

G. Answers to Workbook Supplements

H. Theory Test

I. Answers to Theory Test

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INTRODUCTION

A thorough knowledge and understanding of the aerodynamic and construction characteristics of aircraft structures is essential for the aviation maintenance technician. This knowledge well assures that the A & P will be competent to restore the aircraft structure to its original shape and strength. In this module you will learn the aerodynamic and construction characteristics of aircraft and how they affect necessary repairs.

MODULE OBJECTIVE

After completion of this module, you will be able to identify aerodynamic and construction characteristics of aircraft structures, discuss the loads that are applied to the structures during operation, and explain how flight control surfaces affect aircraft operation. Your competency will be evaluated by completing workbook assignments and by scoring a minimum of 85 percent on the module theory test.

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SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

1. Match terms associated with aerodynamics and construction characteristics to their correct definitions. (1)	Technical Supplement #1 Workbook Supplement #1	
2. Match five major structural stresses imposed on aircraft to examples of each. (1)	AC 65-15A	1-2
3. Label types of metal and wooden spars. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #2	6 8-9
4. Label structural parts of metal and wooden aircraft wings. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #2	3-10 6-13
5. State the purpose of the specific parts of the aircraft wing. (1)	EA-ITP-AB AC 65-15A EA-ITP-AW	3-10 6-13 1:I-II:1-3
6. Select statements related to construction and operational characteristics of wings and their parts. (1)	EA-ITP-AB AC 65-15A EA-ITP-AW	3-10 6-13 1:I-II:1-3
7. Label the three types of fuselage construction. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #3	25-27 2-5
8. Label components of an aircraft empennage and fuselage. (2)	AC 65-15A Workbook Supplement #3	2-5, 16-17
9. Select true statements related to the empennage and its parts. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	14-17 16-17 1:II:3-4
10. Select true statements related to fuselage structures and their parts. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	1-3,24-28 2-6 1:II:7

SPECIFIC OBJECTIVES

11. Label aircraft primary control surfaces. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW Workbook Supplement #4	10-17 3, 18-21 1:II:6
12. Select auxiliary surfaces when given an operational description. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	17-24 21-23 1:II:6
13. Label jet airliner primary and auxiliary control surfaces. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW Workbook Supplement #4	15 20 1:II:5-6
14. Select statements related to the aerodynamics and construction of control surfaces, auxiliary surfaces, and auxiliary devices. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	10-24 18-23 1:II:5-6
15. Discuss common types of structures that support an aircraft on the ground. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	28-31 23 1:II:7
16. Discuss the structures used to house aircraft powerplants. (2)	EA-ITP-AB AC 65-15A EA-ITP-AW	31-32 13-16 1:II:7-8

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INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

I. Implementation Suggestions

(NOTE: A model aircraft with movable control surfaces would be useful for presenting this module. Have students read all available resource materials related to specific objectives.)

Estimated Teaching Time		Theory	Lab
Objective 1	Discuss terms and definitions associated with aerodynamics and construction characteristics using Technical Information Supplement #1. Use Transparency Master #1 to illustrate the terms *airfoil* and *chord* and to introduce the students to the concept of wing camber. Use Transparency Master #2 to illustrate the term *dihedral*. If possible, use a slide presentation to reinforce students' understanding of these terms. Have students complete Workbook Supplement #1.		
Objective 2	Explain the five major structural stresses which affect an aircraft structure. Refer to AC 65-15A, page 2, Figure 1-1 and use a thin-walled rubber hose and two drilled sheets of aluminum with a small-diameter wax candle to illustrate stresses.		
Objective 3	Explain the construction features of metal and wooden spars. Use Transparency Masters #3 and #4. Have available as many actual examples as possible in the classroom or shop for the students to examine.		

Estimated Teaching Time		Theory	Lab
Objectives 4-6	Identify the structural parts of the aircraft wing. Use Transparency Masters #5-#6. Explain the purpose of each individual part and how the parts interact to give the wing its strength. Remove the fabric and metal skins from portions of unairworthy wings to allow students to see the internal structure of an all-metal wing and of a truss-type wing used in a fabric-covered aircraft. Have students complete EA-ITP-AW 1:I-II:1-3 and Workbook Supplement #2.		
Objective 7	Explain the three types of fuselage construction most commonly used in aircraft. Prepare balsa and/or plastic models for the students to view.		
Objectives 8-10	Identify the external features (components) and the internal components for both the empennage and the fuselage using models if available. Explain the specific purpose of each part and how the parts interact to absorb and distribute flight stresses. Use Transparency Masters #7-#10. Have students complete Workbook Supplement #3.		
Objectives 11-12	Have the students view enlarged photographs, drawings, or slides of an airplane wing and empennage. Identify the primary control surfaces, auxiliary surfaces, and auxiliary devices used. Use Transparency Masters #11 and #12.		
Objective 13	Describe the operations of the various primary and auxiliary control surfaces which are used on large turbojet aircraft.		
Objective 14	Discuss the pertinent construction features and the aerodynamic effect that control surfaces, auxiliary surfaces, and auxiliary devices have on an aircraft using an aircraft model. Have the students complete Workbook Supplement #4 and EA-ITP-AW 1:II:3-6. If time allows, have any students that wish actually sit in an aircraft or simulator and operate the controls.		

Estimated Teaching Time		Theory	Lab
Objective 15	Explain the common types of landing gear found on aircraft. Be sure that students understand the operational difference between the tailwheel aircraft and the nosewheel aircraft.		
Objective 16	Explain the nomenclature and the reasons powerplants are attached to the aircraft's structure in various configurations. Have the students complete EA-ITP-AW 1:II:7-8.		

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TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Aerodynamics — Branch of science which deals with the production of lift by the movement of a specially shaped surface through the air

B. Airfoil — Any surface designed to obtain a useful reaction, or lift, from the air through which it moves

EXAMPLES: Wings, control surfaces, and propeller blades

C. Angle of attack — Acute angle formed between the relative wind striking an airfoil and the chord line of the airfoil

D. Axis of an aircraft — One of three straight lines about which an airplane is free to rotate

(NOTE: The longitudinal axis passes through the aircraft from front to rear; the lateral axis, across the aircraft from wing tip to wing tip; and the vertical axis, perpendicular to these other axes, through the center of gravity.)

E. Chord — Imaginary straight line which passes through an airfoil or wing section from the leading edge to the trailing edge

F. Lift — Aerodynamic force that opposes gravity and is produced by downwashing a mass of air equal to the weight of the aircraft

G. Drag — Aerodynamic force on a body acting parallel and opposite to the relative wind; air resistance

H. Center of lift — Resultant of the pressure distributions around the airfoil

I. Pitch — Rotation of an airplane about its lateral axis

J. Roll — Motion of the aircraft about the longitudinal axis

(NOTE: Roll is controlled by the ailerons.)

K. Yaw — Rotation about the vertical axis of an aircraft

L. Control surface — Any of the major flight controls

EXAMPLES: Ailerons, elevator, and rudder

M. Control or trim tab — Small auxiliary hinged portion of a movable control surface that may be adjusted by the pilot in flight to a position which will result in a balance of control forces

N. Stability — Property of a body which causes it, when its equilibrium is disturbed, to develop forces or moments tending to restore the original condition

O. Fuselage — Part of an airplane to which the wing, tail, and landing gear are attached

(NOTE: In single-engine airplanes, the engine is usually attached to the fuselage.)

P. Empennage — Assembly of tail surfaces that are used for both control and stability

Q. Truss fuselage — Aircraft structure usually constructed of welded steel tubing to carry the tensive and compressive loads

(NOTE: A superstructure or auxiliary framework is often attached to the truss to give the structure a desirable aerodynamic shape.)

R. Stressed-skin structure — Structure in which the covering is designed to carry the tension and compression stresses of structural loads

S. Monocoque — Stressed-skin type of structure which uses a minimum of internal structure to support the stress-carrying skin

T. Semi-monocoque — Stressed-skin type of structure in which the skin is supported by a lightweight framework to provide extra rigidity

(NOTE: Most of the larger modern aircraft are of semi-monocoque construction.)

U. Wing spar — Principal spanwise member of the structure of a wing

V. Wing rib — Chordwise member used to give the wing its shape and to transmit the load from the fabric or other covering to the spars

W. Cantilever — Beam or member supported at or near one end only, without external bracing

X. Semi-cantilever — Beam or member supported at one or both ends with external bracing

Y. Dihedral — Positive acute angle between the lateral axis of an airplane and a line through the center of a wing or horizontal stabilizer

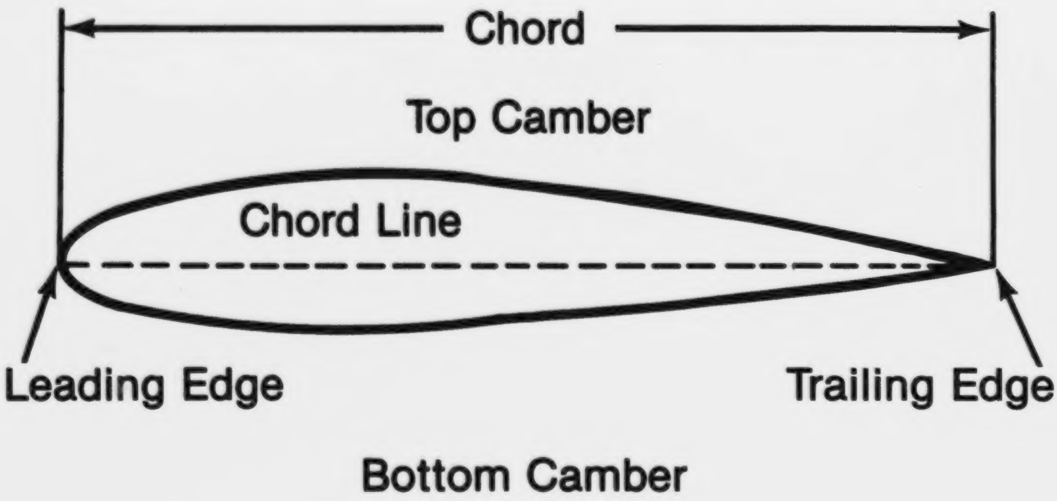
Z. Flap — Hinged, pivoted, or sliding airfoil or plate, normally located at the trailing edge of a wing, extended or deflected to increase the lift and/or drag; generally used at takeoff or landing

AA. Stall strip — Small triangular spoiler attached to the inboard leading edge of some wings to cause the center section of the wing to stall before the tips

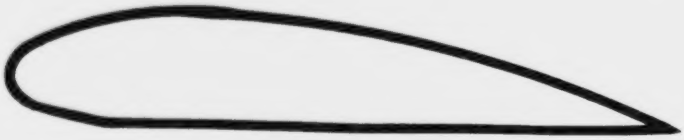
(NOTE: Stall strip assures lateral control throughout the stall.)

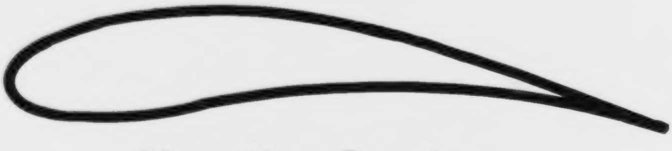
BB. Vortex generator — Small, low-aspect-ratio airfoils mounted in pairs on the upper surface of high-speed aircraft wings; used to bring high energy to the surface of the wing, delaying shock-induced separation

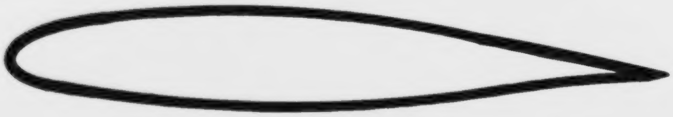
Airfoils in Cross Section


Chord
Top Camber
Chord Line
Leading Edge
Trailing Edge
Bottom Camber

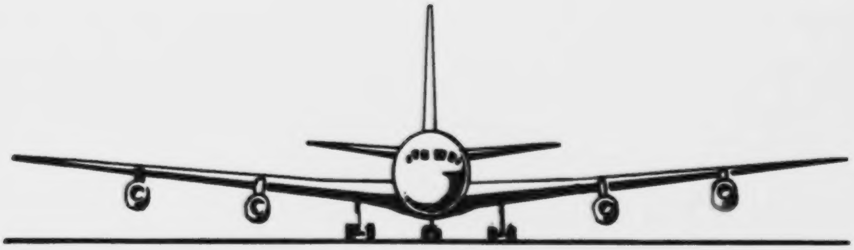
Types of Bottom Cambers


Zero Camber

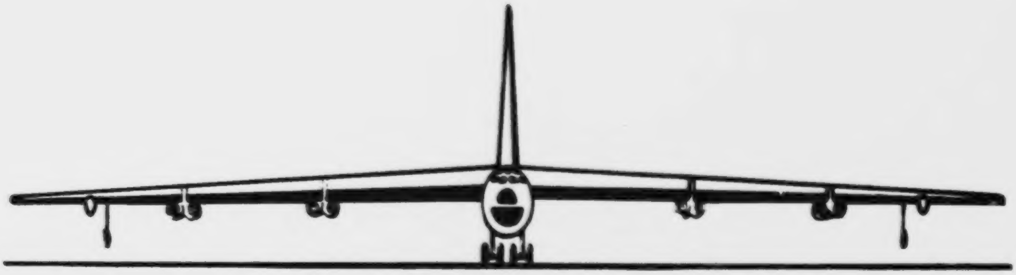

Negative Camber


Positive Camber

Dihedral Angle

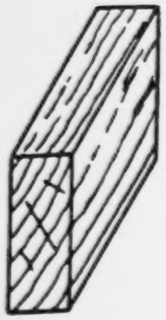


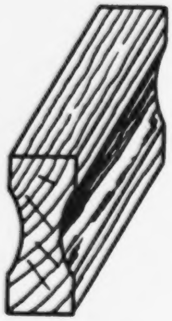
Positive Dihedral

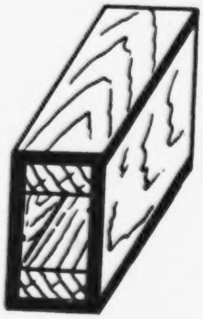


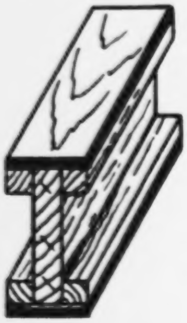
Negative Dihedral

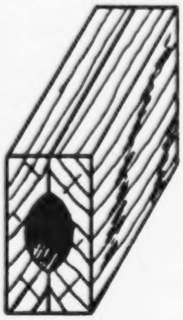
Wooden Spars

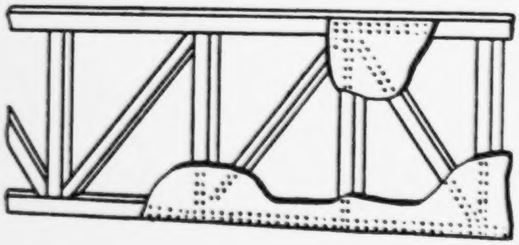

Rectangular
(Solid or
Laminated)


I-Beam,
Externally Routed


Box
(Built-Up)

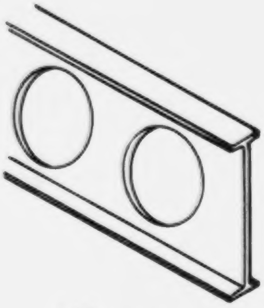

I-Beam, Built-Up


Hollow
(Internally Routed)

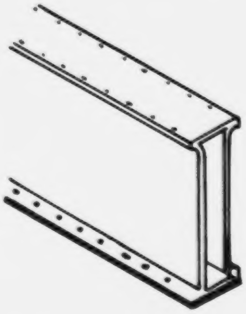

Truss

Source: EA-AC 65-15A.

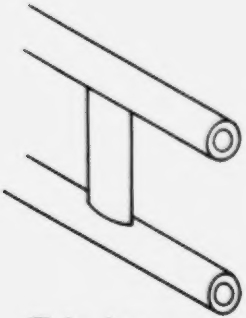
Metal Spars



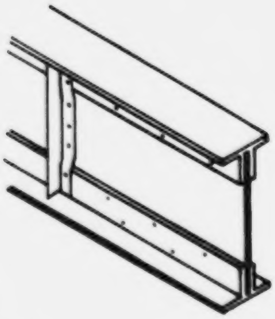
I-Beam,
Extruded, Lightening Holes



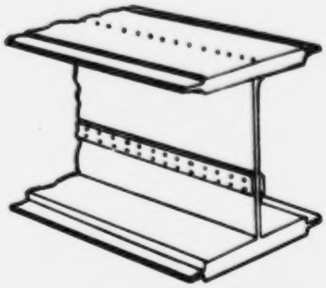
I-Beam, Double-Web
(Built-Up)



Tubular
(Welded, Large Tube)



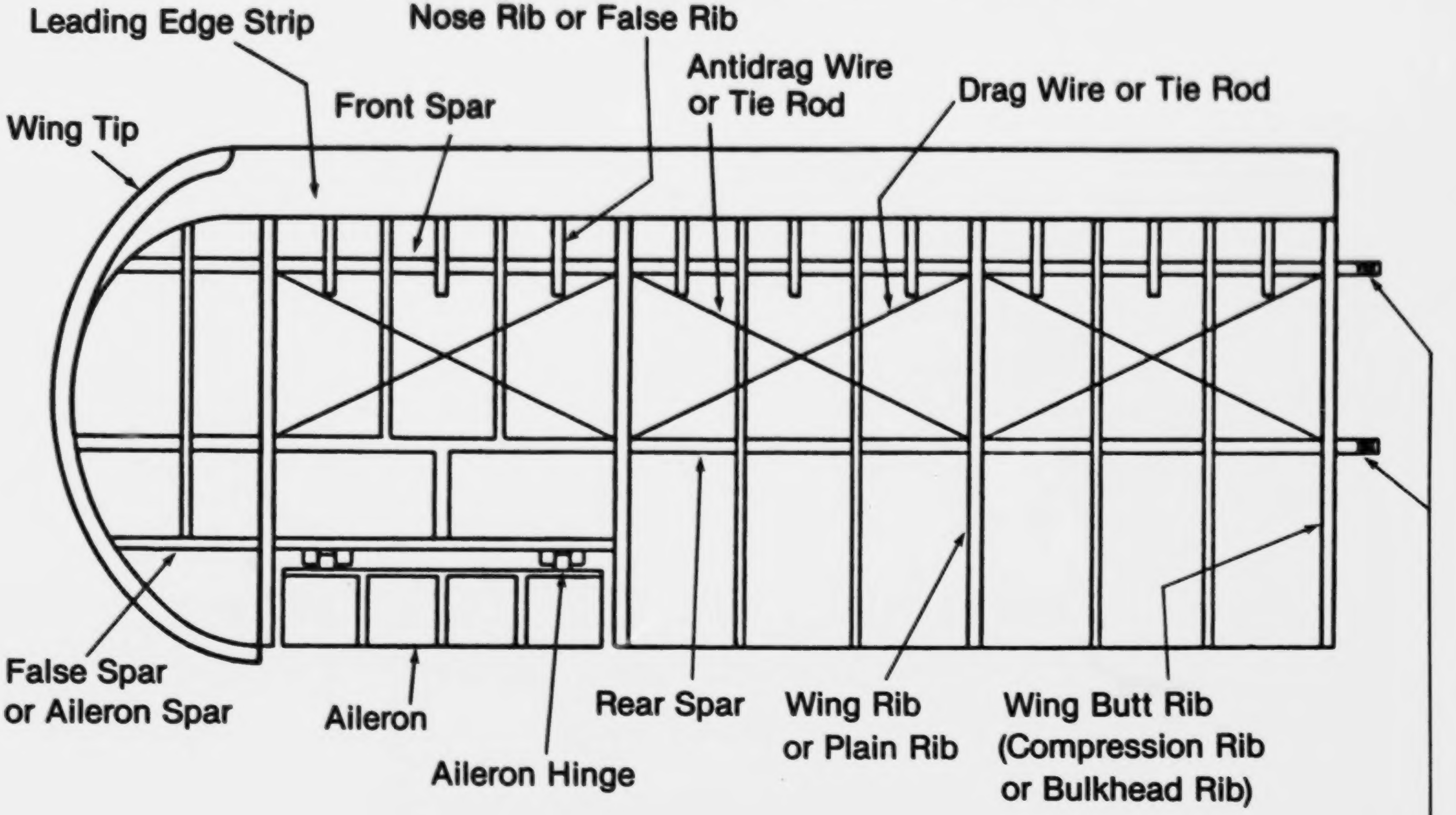
I-Beam, Built-Up



I-Beam, Built-Up,
Fail-Safe Construction

Source: EA-AC 65-15A.

Wooden Wing Internal Structure


Leading Edge Strip
Nose Rib or False Rib
Antidrag Wire or Tie Rod
Drag Wire or Tie Rod
Wing Tip
Front Spar
False Spar or Aileron Spar
Aileron
Aileron Hinge
Rear Spar
Wing Rib or Plain Rib
Wing Butt Rib (Compression Rib or Bulkhead Rib)
Wing Attach Fittings

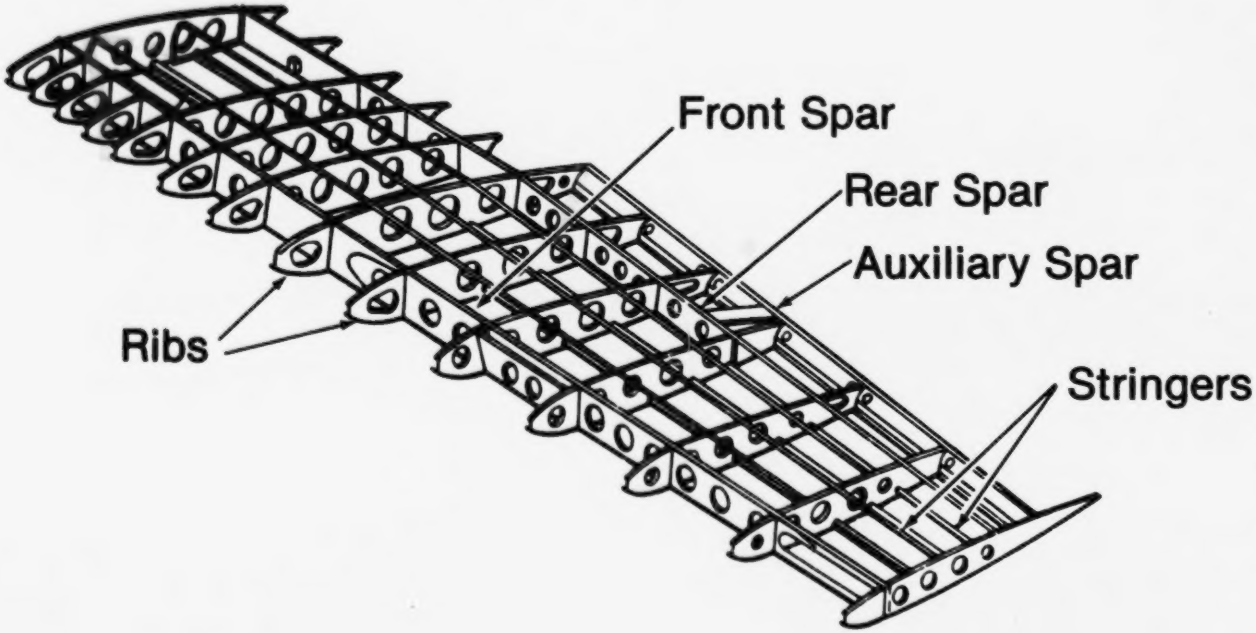
Basic Rib and Spar Structure

Source: EA-AC 65-15A.

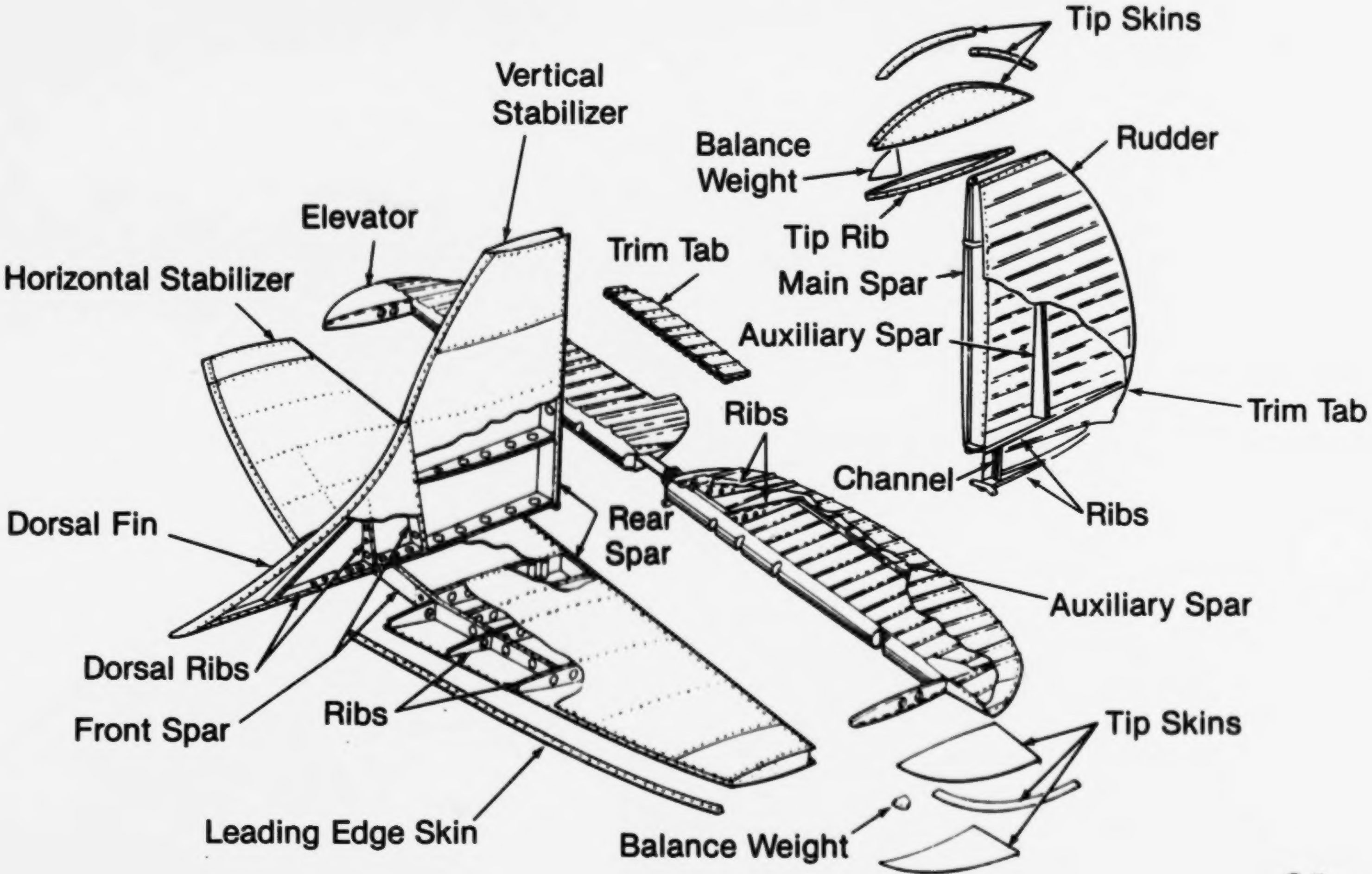
A201A-21

TM #5

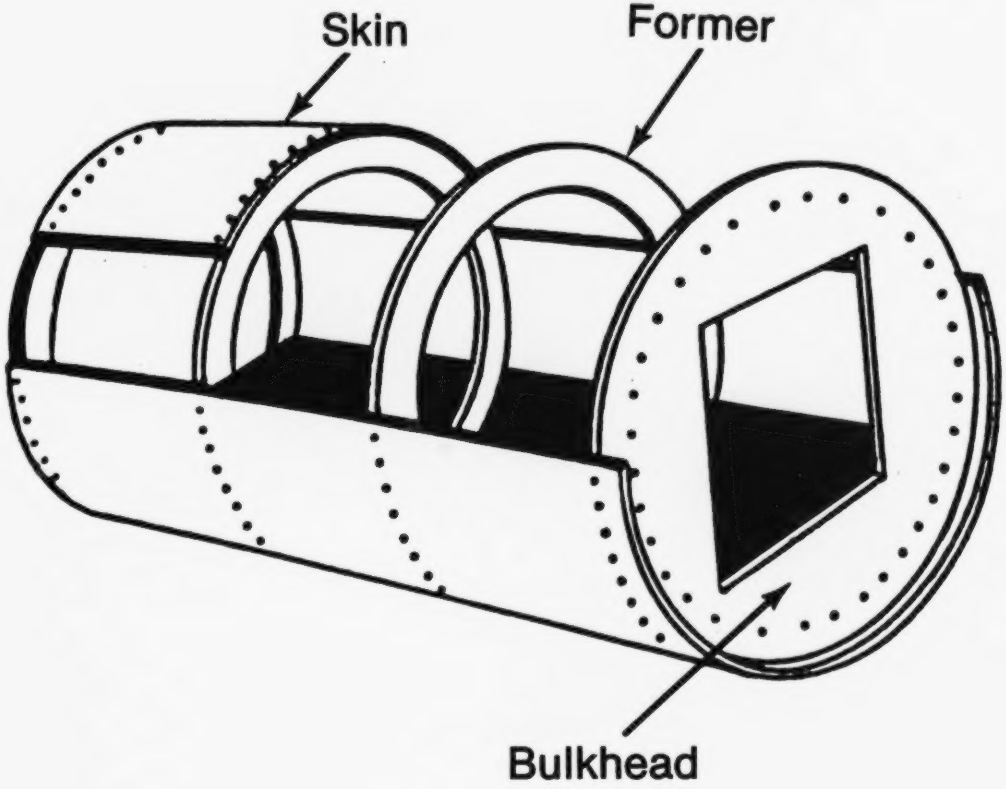
Metal Wing Internal Structure


Front Spar
Rear Spar
Auxiliary Spar
Ribs
Stringers

Empennage Construction Features


Tip Skins
Vertical Stabilizer
Balance Weight
Rudder
Elevator
Trim Tab
Tip Rib
Horizontal Stabilizer
Main Spar
Auxiliary Spar
Trim Tab
Ribs
Channel
Dorsal Fin
Rear Spar
Ribs
Auxiliary Spar
Dorsal Ribs
Front Spar
Ribs
Tip Skins
Leading Edge Skin
Balance Weight

Monocoque Type of Construction

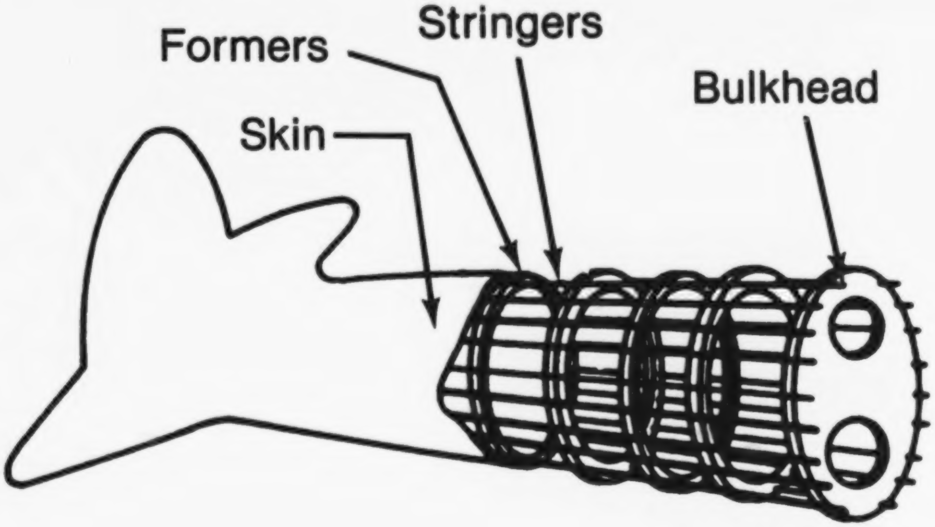

Skin
Former
Bulkhead

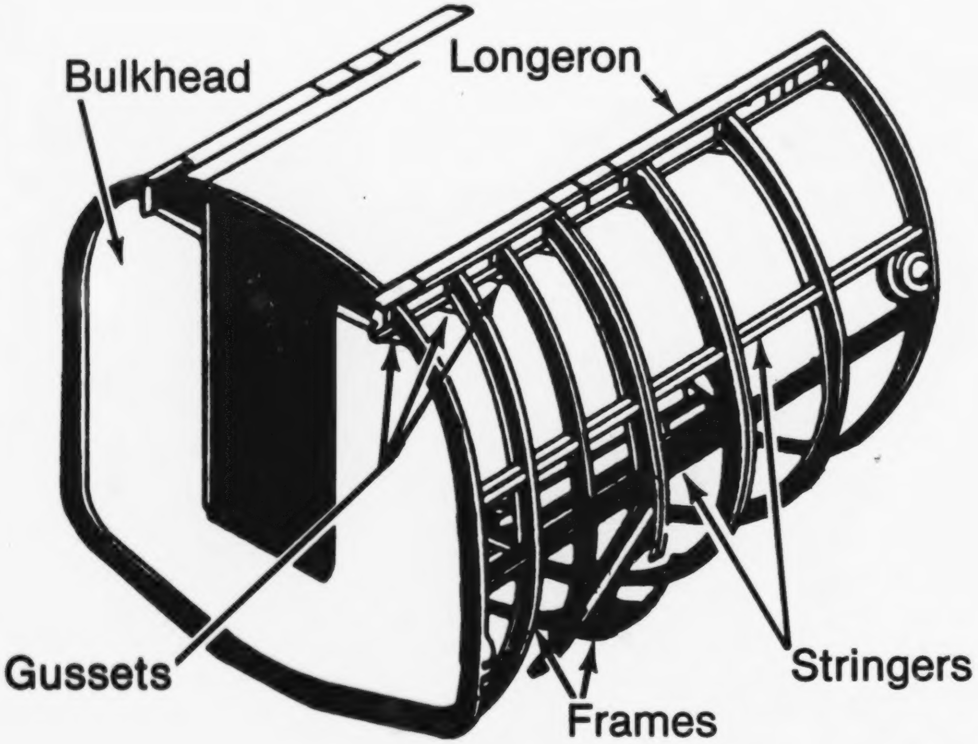
A201A-27

Source: EA-AC 65-15A.

TM #8

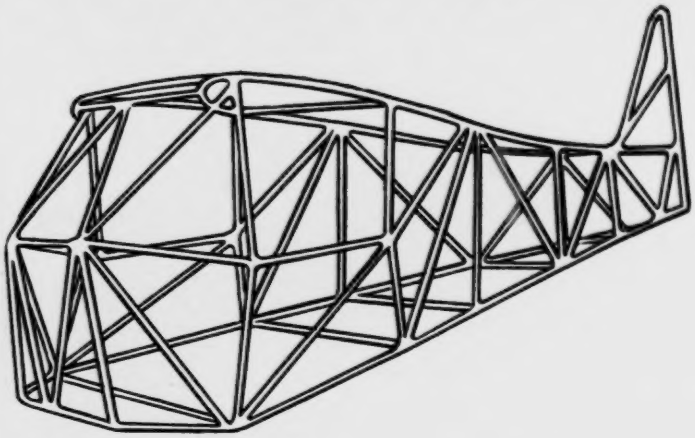
Semi-Monocoque Type of Construction


Formers
Stringers
Bulkhead
Skin

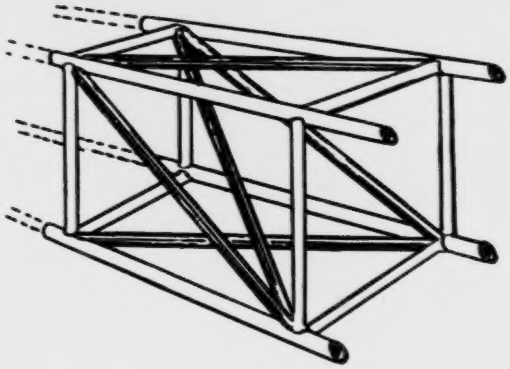

Bulkhead
Longeron
Gussets
Stringers
Frames

Source: EA-AC 65-15A.

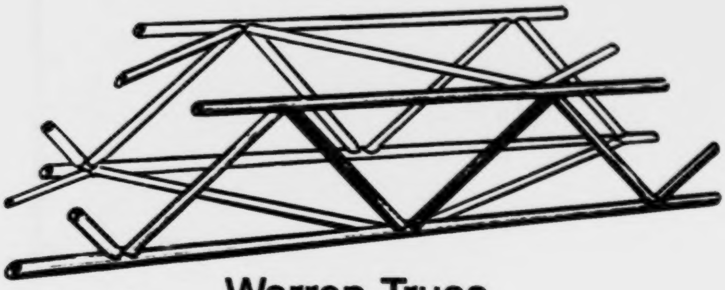
Truss Fuselage Construction



Welded Steel Truss Fuselage



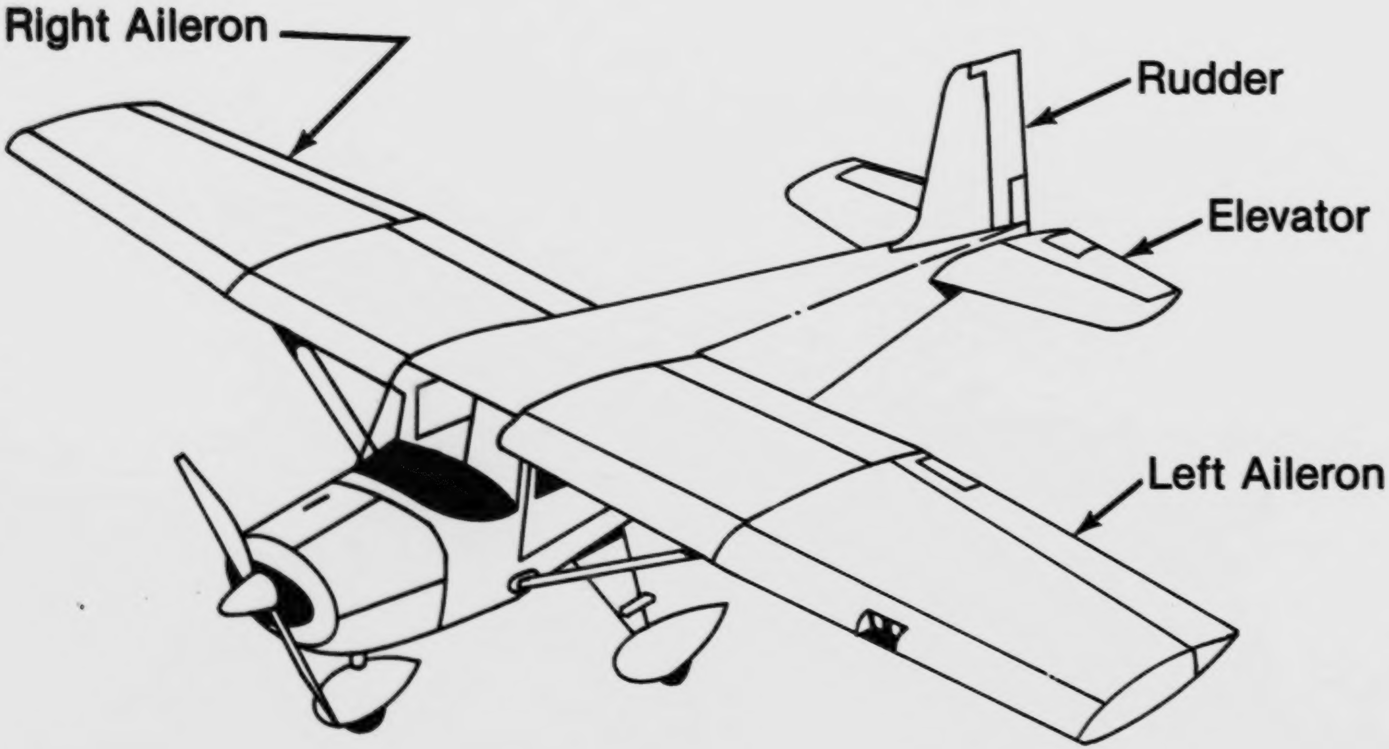
Pratt Truss



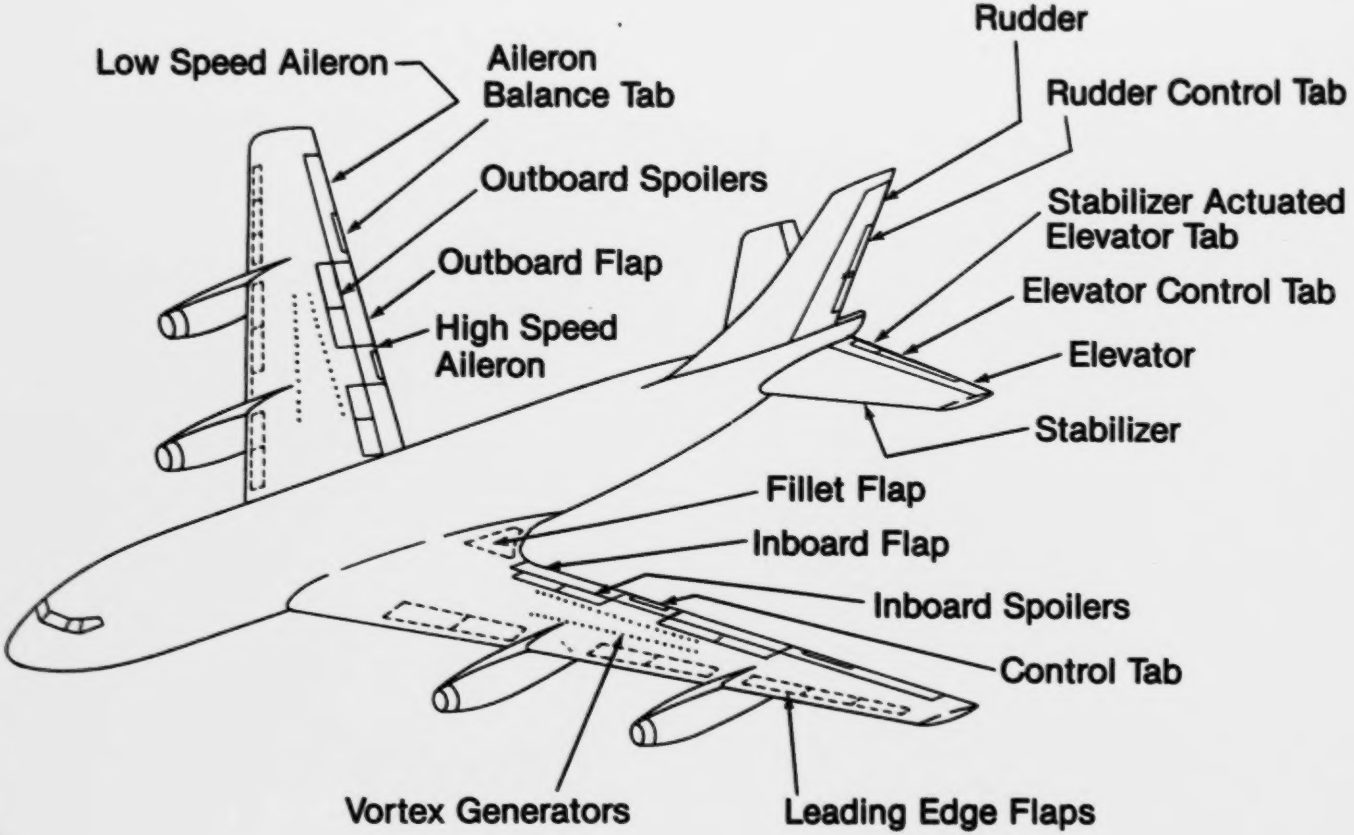
Warren Truss

Reproduced with permission of McGraw-Hill Book Company, *Basic Science for Aerospace Vehicles*, 3rd ed., by James L. McKinley, 1963.

Primary Aircraft Control Surfaces


Right Aileron
Rudder
Elevator
Left Aileron

Jet Airliner Primary and Auxiliary Control Surfaces


Low Speed Aileron
Aileron Balance Tab
Outboard Spoilers
Outboard Flap
High Speed Aileron
Rudder
Rudder Control Tab
Stabilizer Actuated Elevator Tab
Elevator Control Tab
Elevator
Stabilizer
Fillet Flap
Inboard Flap
Inboard Spoilers
Control Tab
Vortex Generators
Leading Edge Flaps

Source: EA-AC 65-15A.

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WORKBOOK SUPPLEMENT #1 — Use Terms and Definitions Related to Aerodynamic and Construction Characteristics of Aircraft Structures to Complete a Word Search

To be able to effectively communicate in the field of aviation maintenance it is important for you to correctly use the language of the profession. This workbook supplement will give you the opportunity to become more competent in communications related to aerodynamic and construction characteristics of aircraft structures.

PART I

Circle the following terms in the word search on the following page. Some words will overlap. Words may be forward, backward, up, down, or diagonal.

Aerodynamics
Airfoil
Angle of attack
Axis of an aircraft
Chord
Lift
Drag
Center of lift
Pitch
Roll
Yaw
Control surface
Control or trim tab
Stability
Fuselage
Empennage
Truss fuselage
Stressed-skin structure
Monocoque
Semi-monocoque
Wing spar
Wing rib
Cantilever
Semi-cantilever
Dihedral
Flap
Stall strip
Vortex generator

WORKBOOK SUPPLEMENT #1

WORKBOOK SUPPLEMENT #1

T	Y	M	F	R	B	G	K	S	V	C	H	D	Z	L	W	N	J	P	M	Q	X	T	F	N
S	C	G	N	Y	J	M	T	M	D	B	F	H	S	T	A	L	L	S	T	R	I	P	V	L
W	J	X	S	L	Q	P	G	O	F	K	D	C	M	B	B	T	L	T	M	V	F	D	G	T
R	X	M	G	C	V	F	J	N	H	L	K	D	P	I	Y	W	Q	A	R	X	H	B	S	X
D	K	T	C	O	N	T	R	O	L	O	R	T	R	I	M	T	A	B	S	T	F	K	G	R
H	Q	D	E	C	H	K	N	C	J	G	L	G	R	C	A	N	T	I	L	E	V	E	R	N
C	M	L	N	F	R	J	V	O	L	D	N	B	S	W	Z	X	V	L	T	Y	G	H	M	X
N	H	C	T	Z	D	N	L	Q	K	I	M	F	V	X	B	Y	D	I	H	E	D	R	A	L
B	Q	R	E	N	C	P	L	U	W	F	S	D	X	G	J	S	H	T	V	Z	T	F	K	B
L	P	Y	R	B	G	Q	W	E	N	H	T	J	Z	K	C	Z	M	Y	X	R	D	N	Q	X
Z	G	C	O	T	K	R	X	J	A	I	R	F	O	I	L	B	N	Q	U	B	H	L	T	R
V	T	S	F	Q	C	J	R	P	L	Y	P	B	M	W	H	D	X	S	Z	G	C	K	S	T
F	V	B	L	C	J	N	H	F	M	D	W	A	T	X	K	G	S	R	F	H	O	M	Z	L
J	D	H	I	M	P	T	U	K	Q	C	N	L	R	Y	S	F	Z	Y	P	J	N	B	M	R
L	W	L	F	Z	S	S	P	T	N	Y	X	B	V	C	U	H	D	G	I	V	T	L	Q	N
N	F	S	T	R	E	S	S	E	D	S	K	I	N	S	T	R	U	C	T	U	R	E	S	T
Z	S	N	Y	L	Q	J	C	O	R	F	B	D	E	G	V	V	H	D	C	K	O	M	Q	R
T	H	R	A	S	F	D	R	X	Y	J	G	L	W	M	B	K	W	N	H	V	L	C	J	P
R	N	G	F	V	B	E	J	K	W	M	A	C	X	H	P	L	Q	Y	G	O	S	K	C	R
P	E	C	L	Z	A	K	T	B	H	G	J	F	Y	A	Q	E	R	S	B	R	U	S	W	B
G	X	P	B	B	N	Z	H	S	E	T	L	K	L	S	C	M	N	Y	J	T	R	D	L	T
K	T	B	N	X	G	Y	C	F	Z	P	N	F	H	J	D	Q	S	N	L	E	F	H	N	V
Y	R	L	Q	F	L	D	N	J	B	S	M	C	Z	K	G	T	V	W	A	X	A	D	G	L
M	P	Y	W	D	E	Q	B	P	C	Y	T	L	D	N	H	X	Z	Y	K	G	C	K	F	Q
S	A	X	I	S	O	F	A	N	A	I	R	C	R	A	F	T	B	Z	M	E	E	R	W	H
W	L	L	N	G	F	P	D	K	R	X	S	M	H	Q	M	B	C	J	T	N	X	L	F	J
X	C	D	I	S	A	H	F	N	W	Z	T	P	L	O	J	D	G	K	V	E	S	P	H	M
B	V	K	C	F	T	M	V	P	D	I	S	Q	N	G	R	O	L	L	W	R	T	V	X	B
N	T	V	R	H	T	L	C	F	G	B	N	S	P	A	K	D	J	G	Y	A	Z	C	L	Q
K	Q	C	X	L	A	N	J	G	H	D	K	G	G	M	P	F	R	S	X	T	R	W	Y	B
H	E	U	Q	O	C	O	N	O	M	I	M	E	S	P	L	H	T	V	Y	O	D	K	N	S
Q	R	F	C	S	K	P	H	L	J	B	D	T	V	P	M	K	W	X	Z	R	L	C	H	R
Z	N	Y	T	Q	C	B	S	V	L	D	F	W	Y	R	A	M	G	Z	H	N	V	T	B	G
T	P	H	S	E	M	I	C	A	N	T	I	L	E	V	E	R	J	B	K	P	H	J	C	K
Z	L	M	J	P	G	F	W	B	Q	B	K	Y	B	S	N	T	L	D	P	C	M	P	W	Q

WORKBOOK SUPPLEMENT #1

PART II

Write the terms listed in Part I in the blanks before their correct definitions.

A. ______________________________ One of three straight lines about which an airplane is free to rotate

B. ______________________________ Beam or member supported at one or both ends with external bracing

C. ______________________________ Stressed-skin type of structure in which the skin is supported by a lightweight framework to provide extra rigidity

D. ______________________________ Aerodynamic force that opposes gravity and is produced by downwashing a mass of air equal to the weight of the aircraft

E. ______________________________ Part of an airplane to which the wing, tail, and landing gear are attached

F. ______________________________ Branch of science which deals with the production of lift by the movement of a specially shaped surface through the air

G. ______________________________ Assembly of tail surfaces that are used for both control and stability

H. ______________________________ Positive acute angle between the lateral axis of an airplane and a line through the center of a wing or horizontal stabilizer

I. ______________________________ Aerodynamic force on a body acting parallel and opposite to the relative wind; air resistance

J. ______________________________ Structure in which the covering is designed to carry the tension and compression stresses of structural loads

K. ______________________________ Rotation of an airplane about its lateral axis

L. ______________________________ Small triangular spoiler attached to the inboard leading edge of some wings to cause the center section of the wing to stall before the tips

M. ______________________________ Resultant of the pressure distributions around the airfoil

N. ______________________________ Chordwise member used to give the wing its shape and to transmit the load from the fabric or other covering to the spars

O. ______________________ Motion of the aircraft about the longitudinal axis

P. ______________________ Hinged, pivoted, or sliding airfoil or plate, normally located at the trailing edge of a wing, extended or deflected to increase the lift and/or drag; generally used at takeoff or landing

Q. ______________________ Any surface designed to obtain a useful reaction, or lift, from the air through which it moves

R. ______________________ Stressed-skin type of structure which uses a minimum of internal structure to support the stress-carrying skin

S. ______________________ Any of the major flight controls

T. ______________________ Small, low-aspect-ratio airfoils mounted in pairs on the upper surface of high-speed aircraft wings; used to bring high energy to the surface of the wing, delaying shock-induced separation

U. ______________________ Rotation about the vertical axis of an aircraft

V. ______________________ Beam or member supported at or near one end only, without external bracing

W. ______________________ Property of a body which causes it, when its equilibrium is disturbed, to develop forces or moments tending to restore the original condition

X. ______________________ Acute angle formed between the relative wind striking an airfoil and the chord line of the airfoil

Y. ______________________ Aircraft structure usually constructed of welded steel tubing to carry the tensive and compressive loads

Z. ______________________ Small auxiliary hinged portion of a movable control surface that may be adjusted by the pilot in flight to a position which will result in a balance of control forces

AA. ______________________ Principal spanwise member of the structure of a wing

BB. ______________________ Imaginary straight line which passes through an airfoil or wing section from the leading edge to the trailing edge

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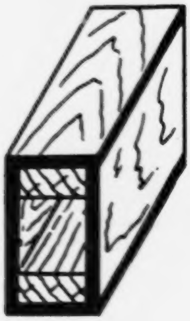
WORKBOOK SUPPLEMENT #2 — Label Types of Metal and Wooden Spars and Structural Parts of Aircraft Wings

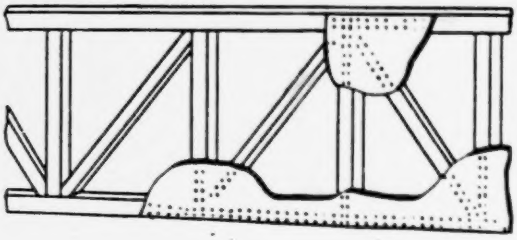
Can you identify the structural parts of an aircraft wing and the eleven types of spars used in wing structures? As an airframe technician, you will use this basic but very important knowledge almost daily in the repair and maintenance of airframe structures. This workbook supplement will give you an opportunity to gain this knowledge.

PART I

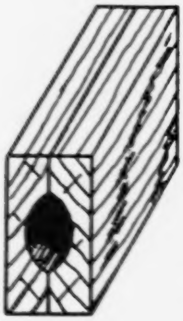
Label the following types of spars. Write the correct names in the blanks.



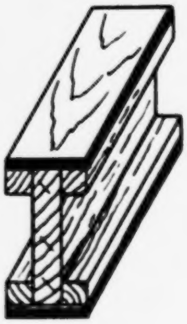
A. ______________________________



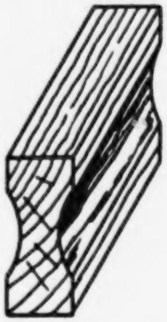
B. ______________________________

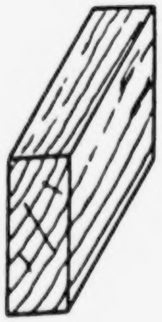


C. ______________________________



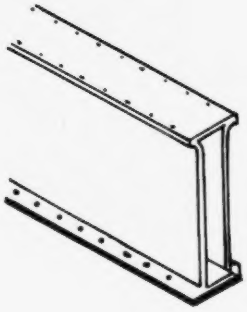
D. ______________________________

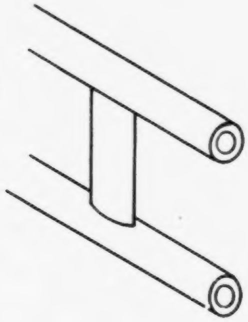




E. ______________________________

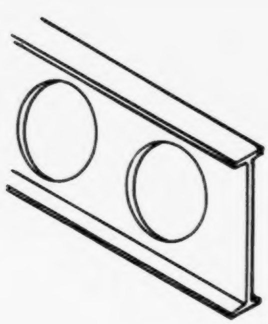
F. ______________________________

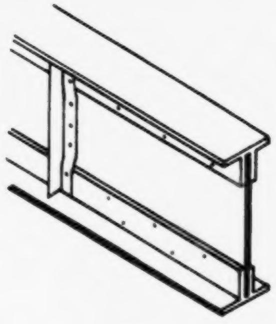




G. ______________________________

H. ______________________________

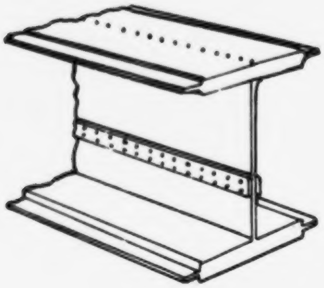




I. ______________________________

J. ______________________________

WORKBOOK SUPPLEMENT #2



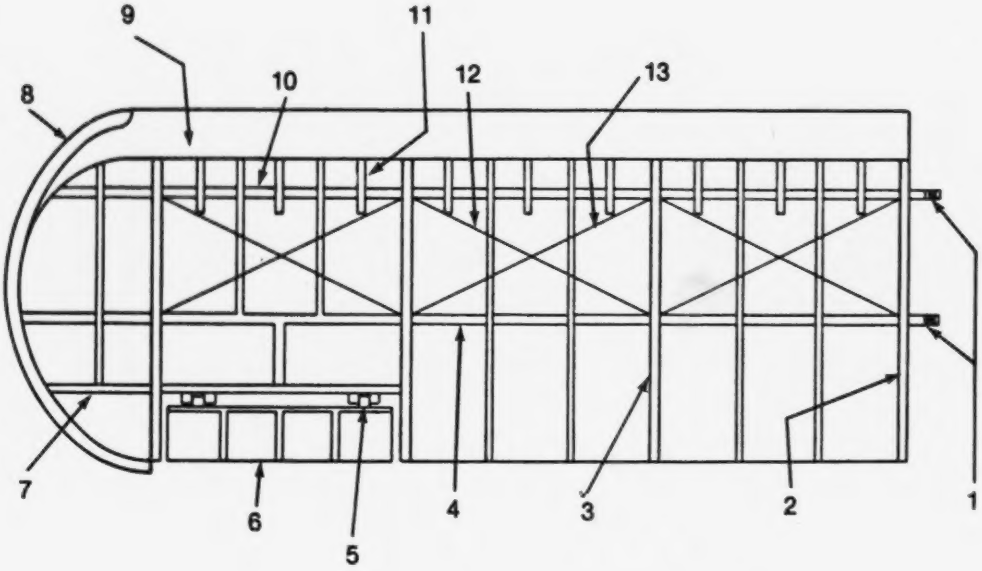
K. ______________________________

WORKBOOK SUPPLEMENT #2

PART II

Label the structural parts of the following aircraft wings. Write the correct names in the blanks.

A. Wooden wing


9
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1. ______________________

2. ______________________

3. ______________________

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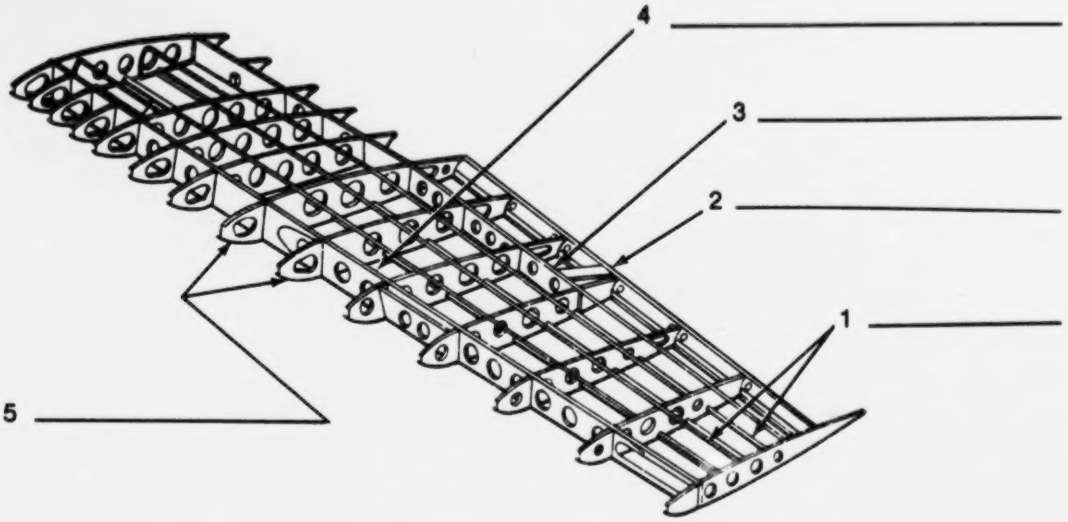
12. ______________________

13. ______________________

WORKBOOK SUPPLEMENT #2

B. Metal wing



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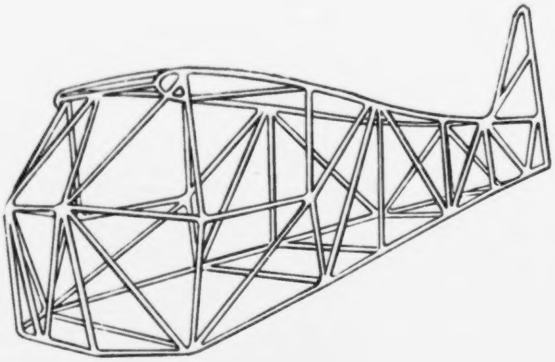
WORKBOOK SUPPLEMENT #3 — Label Types of Fuselage Construction and Components of an Aircraft Empennage and Fuselage

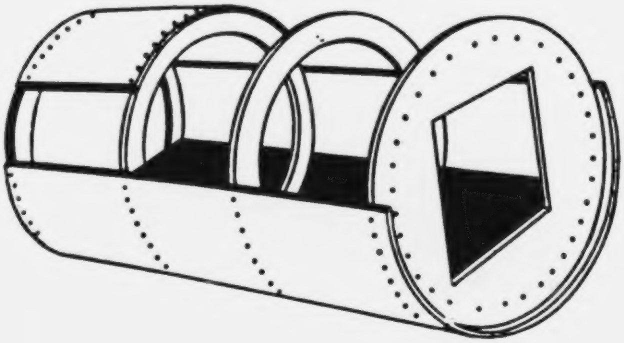
To properly maintain and repair an airframe structure, the aviation maintenance technician must be able to determine the type of fuselage construction and identify the fuselage and empennage components. In this workbook supplement you will label the types of fuselage construction as well as the components of both the fuselage and empennage.

PART I

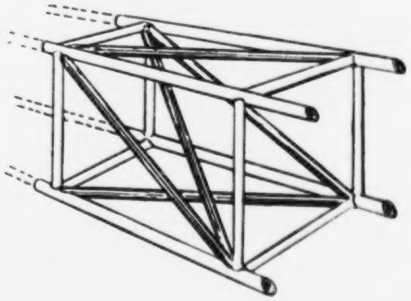
Label the following types of fuselage construction. Write the correct names in the blanks.



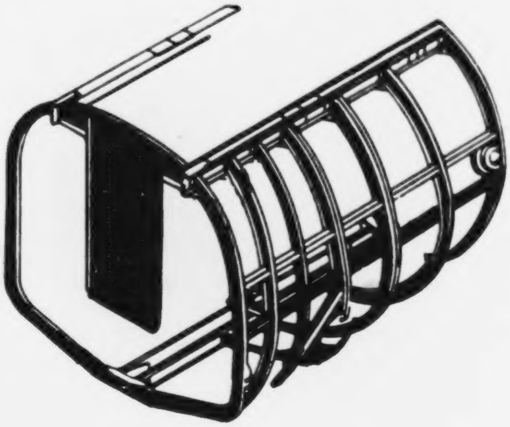
A. ______________________________



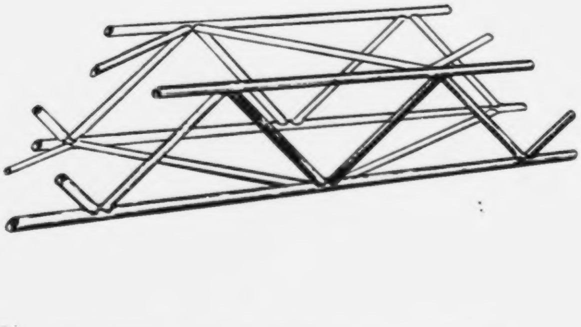
B. ______________________________



C. ______________________________



D. ______________________________



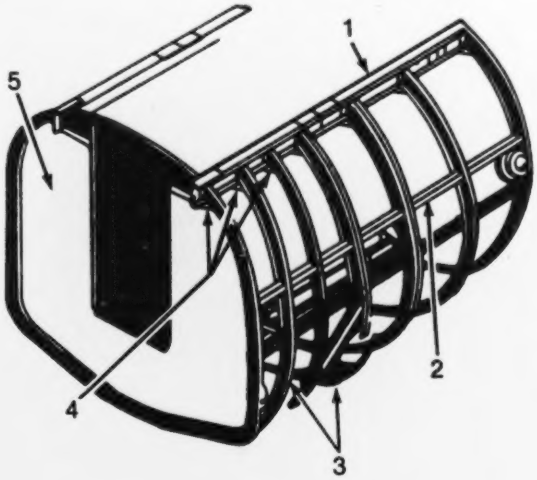
E. ______________________________

WORKBOOK SUPPLEMENT #3

PART II

Label the components of the following aircraft fuselages. Write the correct names in the blanks.

A.

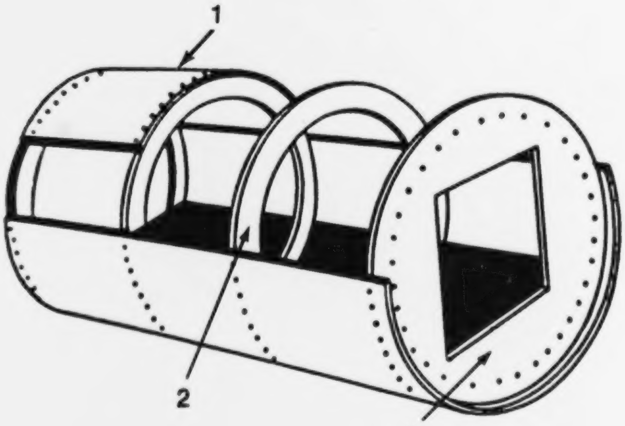


1. ______________________ 4. ______________________

2. ______________________ 5. ______________________

3. ______________________

B.



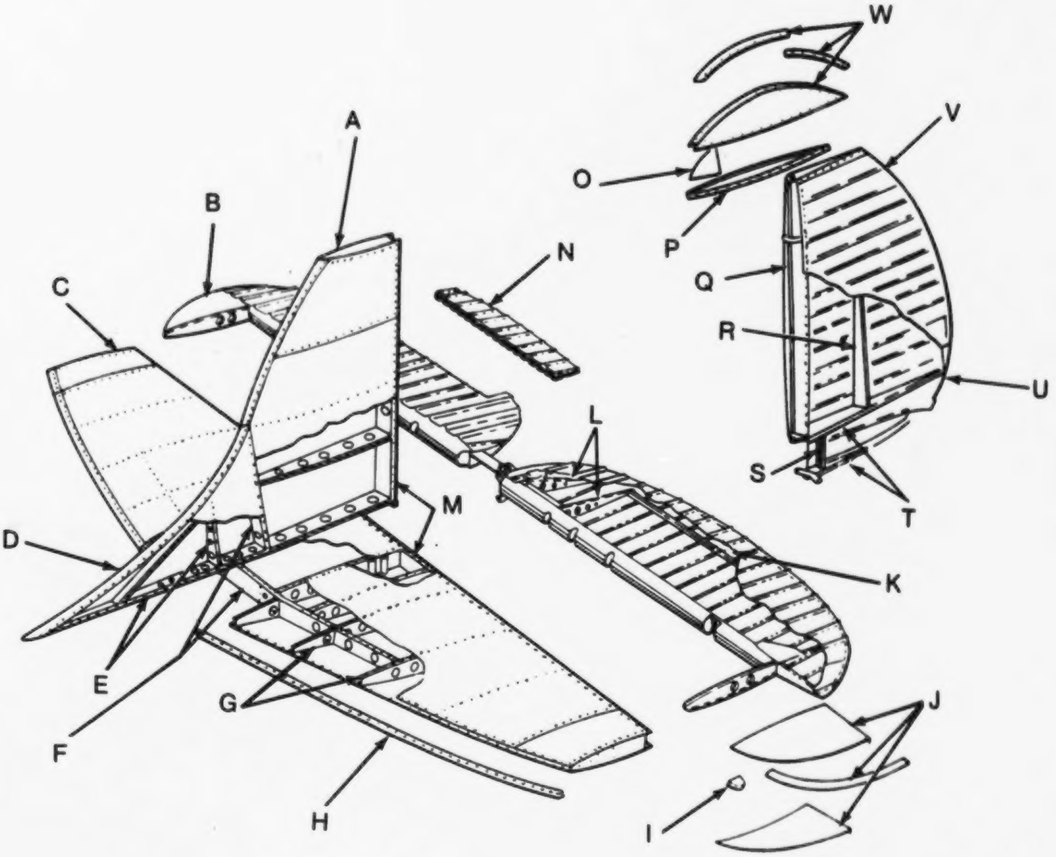
1. ______________________ 3. ______________________

2. ______________________

WORKBOOK SUPPLEMENT #3

PART III

Label the components of the aircraft empennage. Write the correct names in the blanks on the following page.


W
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H
I

WORKBOOK SUPPLEMENT #3

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

G. ______________________________

H. ______________________________

I. ______________________________

J. ______________________________

K. ______________________________

L. ______________________________

M. ______________________________

N. ______________________________

O. ______________________________

P. ______________________________

Q. ______________________________

R. ______________________________

S. ______________________________

T. ______________________________

U. ______________________________

V. ______________________________

W. ______________________________

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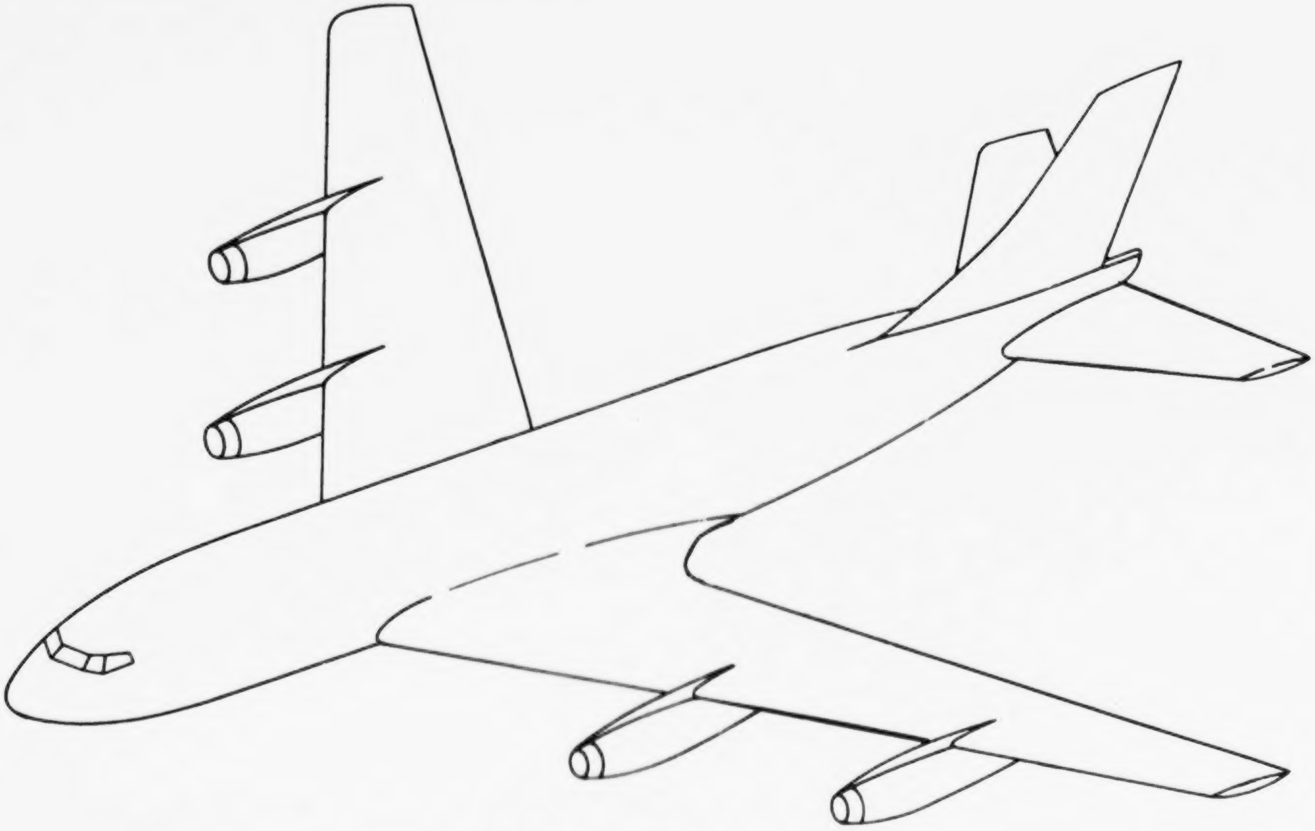
WORKBOOK SUPPLEMENT #4 — Label Aircraft Control Surfaces, Auxiliary Surfaces, and Auxiliary Devices

An airplane in flight moves in three dimensions. The movements in these three dimensions are called roll, pitch, and yaw. A pilot maintains control over these movements by means of control surfaces. An airplane also has auxiliary surfaces and auxiliary devices which are used to extend the airplane's basic design capabilities. These types of auxiliary surfaces or devices might be used to provide additional lift and drag, to prevent boundary layer separation, to relieve control pressure, and for a variety of other tasks. The aviation maintenance technician needs to thoroughly understand how control surfaces, auxiliary surfaces, and auxiliary devices function and how to troubleshoot and maintain aircraft as skillfully as possible.

Sketch and label all control surfaces, auxiliary surfaces, and auxiliary devices on the drawing on the next page. Try to complete this drawing with as little outside reference as possible. Keep a count of the number of times you must refer to your resource material. When completed, you should have labeled 17 items.

WORKBOOK SUPPLEMENT #4

A201A-56



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ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #1

PART I

T	Y	M	F	R	B	G	K	S	V	C	H	D	Z	L	W	N	J	P	M	Q	X	T	F	N
S	C	G	N	Y	J	M	T	M	D	B	F	H	S	T	A	L	L	S	T	R	I	P	V	L
W	J	X	S	L	Q	P	G	O	F	K	D	C	M	B	B	T	L	T	M	V	F	D	G	T
R	X	M	G	C	V	F	J	N	H	L	K	D	P	I	Y	W	Q	A	R	X	H	B	S	X
D	K	T	C	O	N	T	R	O	L	O	R	T	R	I	M	T	A	B	S	T	F	K	G	R
H	Q	D	E	C	H	K	N	C	J	G	L	G	R	C	A	N	T	I	L	E	V	E	R	N
C	M	L	N	F	R	J	V	O	L	D	N	B	S	W	Z	X	V	L	T	Y	G	H	M	X
N	H	C	T	Z	D	N	L	Q	K	I	M	F	V	X	B	Y	D	I	H	E	D	R	A	L
B	Q	R	E	N	C	P	L	U	W	F	S	D	X	G	J	S	H	T	V	Z	T	F	K	B
L	P	Y	R	B	G	Q	W	E	N	H	T	J	Z	K	C	Z	M	Y	X	R	D	N	Q	X
Z	G	C	O	T	K	R	X	J	A	I	R	F	O	I	L	B	N	Q	U	B	H	L	T	R
V	T	S	F	Q	C	J	R	P	L	Y	P	B	M	W	H	D	X	S	Z	G	C	K	S	T
F	V	B	L	C	J	N	H	F	M	D	W	A	T	X	K	G	S	R	F	H	O	M	Z	L
J	D	H	I	M	P	T	U	K	Q	C	N	L	R	Y	S	F	Z	Y	P	J	N	B	M	R
L	W	L	F	Z	S	S	P	T	N	Y	X	B	V	C	U	H	D	G	I	V	T	L	Q	N
N	F	S	T	R	E	S	S	E	D	S	K	I	N	S	T	R	U	C	T	U	R	E	S	T
Z	S	N	Y	L	Q	J	C	O	R	F	B	D	E	G	V	V	H	D	C	K	O	M	Q	R
T	H	R	A	S	F	D	R	X	Y	J	G	L	W	M	B	K	W	N	H	V	L	C	J	P
R	N	G	F	V	B	E	J	K	W	M	A	C	X	H	P	L	Q	Y	G	O	S	K	C	R
P	E	C	L	Z	A	K	T	B	H	G	J	F	Y	A	Q	E	R	S	B	R	U	S	W	B
G	X	P	B	B	N	Z	H	S	E	T	L	K	L	S	C	M	N	Y	J	T	R	D	L	T
K	T	B	N	X	G	Y	C	F	Z	P	N	F	H	J	D	Q	S	N	L	E	F	H	N	V
Y	R	L	Q	F	L	D	N	J	B	S	M	C	Z	K	G	T	V	W	A	X	A	D	G	L
M	P	Y	W	D	E	Q	B	P	C	Y	T	L	D	N	H	X	Z	Y	K	G	C	K	F	Q
S	A	X	I	S	O	F	A	N	A	I	R	C	R	A	F	T	B	Z	M	E	E	R	W	H
W	L	L	N	G	F	P	D	K	R	X	S	M	H	Q	M	B	C	J	T	N	X	L	F	J
X	C	D	I	S	A	H	F	N	W	Z	T	P	L	O	J	D	G	K	V	E	S	P	H	M
B	V	K	C	F	T	M	V	P	D	I	S	Q	N	G	R	O	L	L	W	R	T	V	X	B
N	T	V	R	H	T	L	C	F	G	B	N	S	P	A	K	D	J	G	Y	A	Z	C	L	Q
K	Q	C	X	L	A	N	J	G	H	D	K	G	G	M	P	F	R	S	X	T	R	W	Y	B
H	E	U	Q	O	C	O	N	O	M	I	M	E	S	P	L	H	T	V	Y	O	D	K	N	S
Q	R	F	C	S	K	P	H	L	J	B	D	T	V	P	M	K	W	X	Z	R	L	C	H	R
Z	N	Y	T	Q	C	B	S	V	L	D	F	W	Y	R	A	M	G	Z	H	N	V	T	B	G
T	P	H	S	E	M	I	C	A	N	T	I	L	E	V	E	R	J	B	K	P	H	J	C	K
Z	L	M	J	P	G	F	W	B	Q	B	K	Y	B	S	N	T	L	D	P	C	M	P	W	Q

ANSWERS TO WORKBOOK SUPPLEMENTS

PART II

A. Axis of an aircraft
B. Semi-cantilever
C. Semi-monocoque
D. Lift
E. Fuselage
F. Aerodynamics
G. Empennage
H. Dihedral
I. Drag
J. Stressed-skin structure
K. Pitch
L. Stall strip
M. Center of lift
N. Wing rib
O. Roll
P. Flap
Q. Airfoil
R. Monocoque
S. Control surface
T. Vortex generator
U. Yaw
V. Cantilever
W. Stability
X. Angle of attack
Y. Truss fuselage
Z. Control or trim tab
AA. Wing spar
BB. Chord

Workbook Supplement #2

PART I

A. Box
B. Truss
C. Hollow
D. I-beam, built-up
E. I-beam, externally routed
F. Rectangular
G. I-beam, double-web
H. Tubular
I. I-beam, extruded, lightening holes
J. I-beam, built-up
K. I-beam, built-up, fail-safe construction

PART II

A. 1. Wing attach fittings
   2. Wing butt rib
   3. Wing rib or plain rib
   4. Rear spar
   5. Aileron hinge
   6. Aileron
   7. False spar or aileron spar
   8. Wing tip
   9. Leading edge strip
   10. Front spar
   11. Nose rib or false rib
   12. Antidrag wire or tie rod
   13. Drag wire or tie rod

B. 1. Stringers
   2. Auxiliary spar
   3. Rear spar
   4. Front spar
   5. Ribs

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #3

PART I

A. Welded steel truss
B. Monocoque
C. Pratt truss
D. Semi-monocoque
E. Warren truss

PART II

A.
  1. Longeron
  2. Stringer
  3. Frames
  4. Gussets
  5. Bulkhead

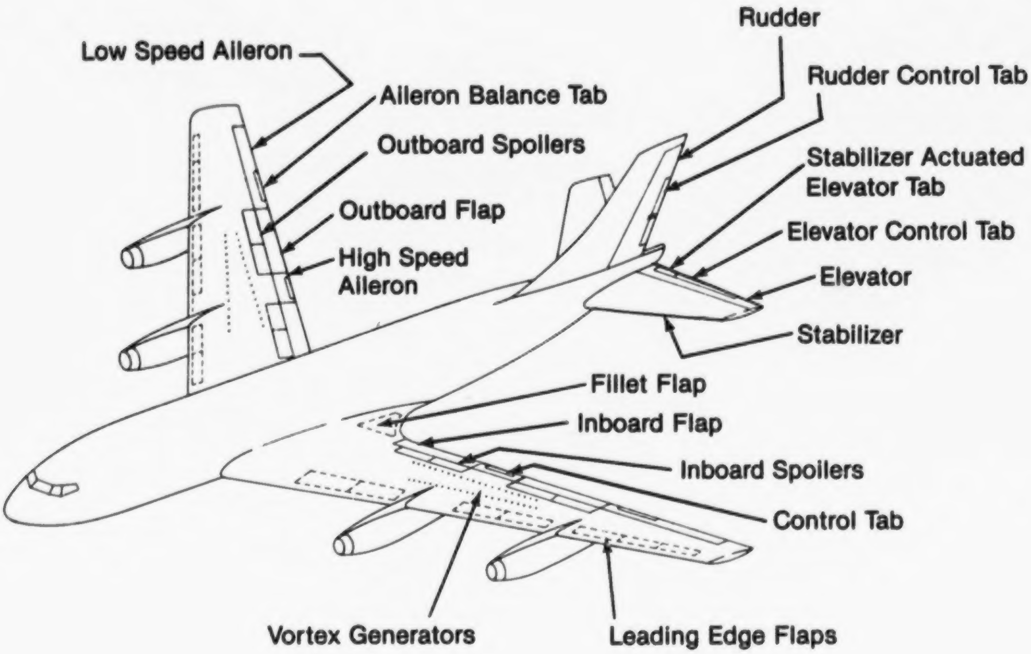
B.
  1. Skin
  2. Former
  3. Bulkhead

PART III

A. Vertical stabilizer
B. Elevator
C. Horizontal stabilizer
D. Dorsal fin
E. Dorsal ribs
F. Front spar
G. Ribs
H. Leading edge skin
I. Balance weight
J. Tip skins
K. Auxiliary spar
L. Ribs
M. Rear spar
N. Trim tab
O. Balance weight
P. Tip rib
Q. Main spar
R. Auxiliary spar
S. Channel
T. Ribs
U. Trim tab
V. Rudder
W. Tip skins

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #4


Low Speed Aileron
Aileron Balance Tab
Outboard Spoilers
Outboard Flap
High Speed Aileron
Rudder
Rudder Control Tab
Stabilizer Actuated Elevator Tab
Elevator Control Tab
Elevator
Stabilizer
Fillet Flap
Inboard Flap
Inboard Spoilers
Control Tab
Vortex Generators
Leading Edge Flaps

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
IDENTIFY AERODYNAMIC AND CONSTRUCTION CHARACTERISTICS OF AIRCRAFT STRUCTURES
A201-A

THEORY TEST

1. Match terms associated with aerodynamics and construction characteristics to their correct definitions. Write the correct numbers in the blanks.

_____a. Small, low-aspect-ratio airfoils mounted in pairs on the upper surface of high-speed aircraft wings; used to bring high energy to the surface of the wing, delaying shock-induced separation

_____b. Part of an airplane to which the wing, tail, and landing gear are attached

_____c. Aerodynamic force on a body acting parallel and opposite to the relative wind; air resistance

_____d. Stressed-skin type of structure which uses a minimum of internal structure to support the stress-carrying skin

_____e. Small triangular spoiler attached to the inboard leading edge of some wings to cause the center section of the wing to stall before the tips

_____f. Motion of the aircraft about the longitudinal axis

_____g. Beam or member supported at one or both ends with external bracing

_____h. Property of a body which causes it, when its equilibrium is disturbed, to develop forces or moments tending to restore the original condition

_____i. Principal spanwise member of the structure of a wing

_____j. Imaginary straight line which passes through an airfoil or wing section from the leading edge to the trailing edge

1. Monocoque
2. Semi-cantilever
3. Drag
4. Stability
5. Vortex generator
6. Roll
7. Fuselage
8. Stall strip
9. Wing spar
10. Chord

THEORY TEST

______k. Chordwise member used to give the wing its shape and to transmit the load from the fabric or other covering to the spars

______l. Any surface designed to obtain a useful reaction, or lift, from the air through which it moves

______m. Assembly of tail surfaces that are used for both control and stability

______n. One of three straight lines about which an airplane is free to rotate

______o. Small auxiliary hinged portion of a movable control surface that may be adjusted by the pilot in flight to a position which will result in a balance of control forces

______p. Rotation of an airplane about its lateral axis

______q. Rotation about the vertical axis of an aircraft

______r. Stressed-skin type of structure in which the skin is supported by a lightweight framework to provide extra rigidity

______s. Acute angle formed between the relative wind striking an airfoil and the chord line of the airfoil

______t. Hinged, pivoted, or sliding airfoil or plate, normally located at the trailing edge of a wing, extended or deflected to increase the lift and/or drag; generally used at takeoff or landing

______u. Resultant of the pressure distributions around the airfoil

______v. Positive acute angle between the lateral axis of an airplane and a line through the center of a wing or horizontal stabilizer

______w. Branch of science which deals with the production of lift by the movement of a specially shaped surface through the air

11. Empennage
12. Control or trim tab
13. Angle of attack
14. Yaw
15. Semi-monocoque
16. Wing rib
17. Pitch
18. Axis of an aircraft
19. Airfoil
20. Center of lift
21. Flap
22. Dihedral
23. Aerodynamics

______x. Structure in which the covering is designed to carry the tension and compression stresses of structural loads

______y. Any of the major flight controls

______z. Beam or member supported at or near one end only, without external bracing

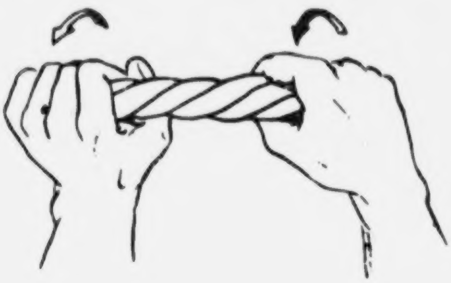
______aa. Aerodynamic force that opposes gravity and is produced by downwashing a mass of air equal to the weight of the aircraft

______bb. Aircraft structure usually constructed of welded steel tubing to carry the tensive and compressive loads

24. Control surface
25. Truss fuselage
26. Lift
27. Cantilever
28. Stressed-skin structure

2. Match five major structural stresses imposed on aircraft to examples of each. Write the correct numbers in the blanks.

______a.

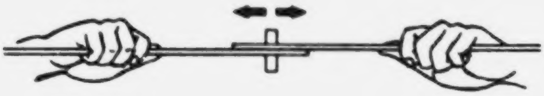


Source: EA-AC 65-15A.

______b. Structural stress that results when the engine pulls the aircraft forward, but air resistance holds it back

______c. Structural stress that tends to shorten or squeeze aircraft parts

______d.



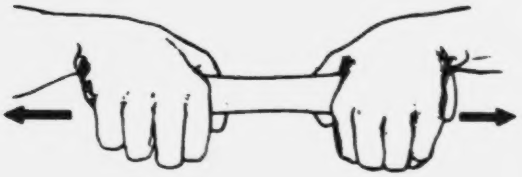
Source: EA-AC 65-15A.

______e. During flight, structural stress that is created when the spars of the wing pull apart on the top of the wing and push together on the bottom of the wing

1. Tension
2. Compression
3. Torsion
4. Shear
5. Bending

1. Tension
2. Compression
3. Torsion
4. Shear
5. Bending

______f.

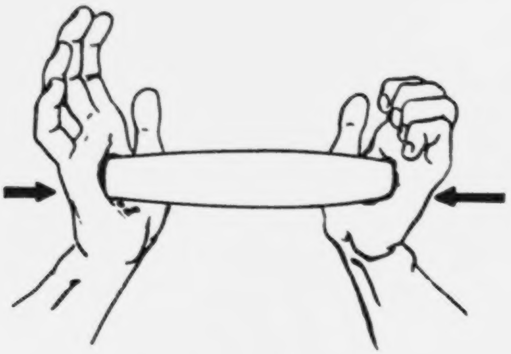


Source: EA-AC 65-15A.

______g. Structural stress that occurs to the rivet when two riveted plates are in tension

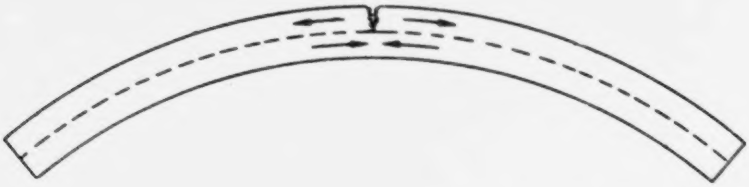
______h. Structural stress created during flight when the engine tends to twist the aircraft from side to side while other aircraft components hold the aircraft on course

______i.



Source: EA-AC 65-15A.

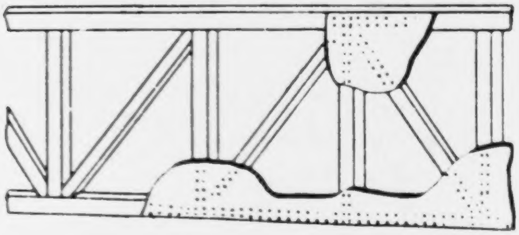
______j.



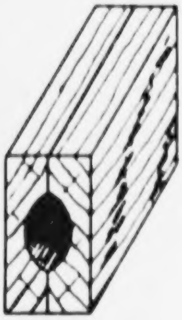
Source: EA-AC 65-15A.

3. The spar is one of the main structural parts of the wing. Older aircraft use wooden spars, but the more modern aircraft use metal spars. Label the following types of metal and wooden spars. Write the correct names in the blanks.

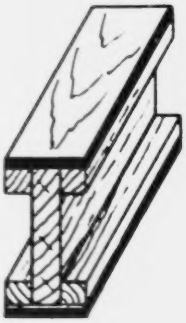
Wooden spars



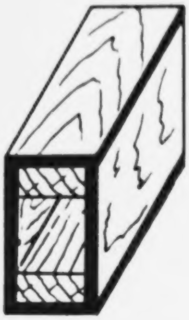
a. ______________________________



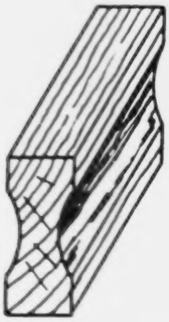
b. ______________________________



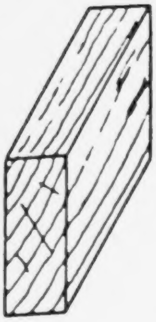
c. ______________________________



d. ______________________________

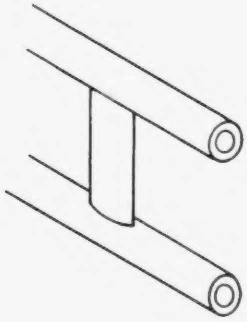


e. ______________________________

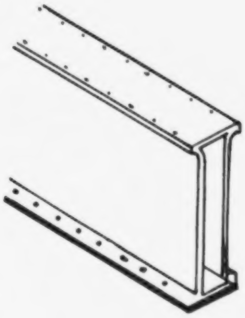


f. ______________________________

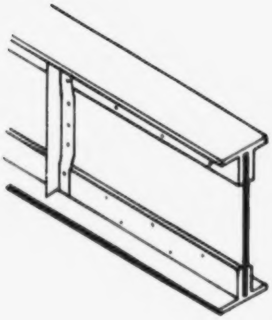
Metal spars



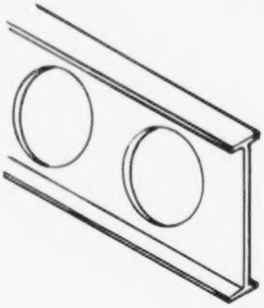
a. ______________________



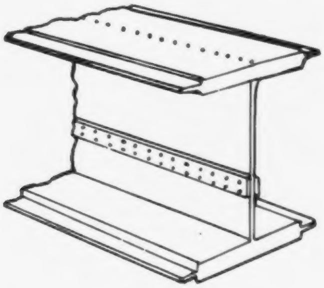
b. ______________________



c. ______________________



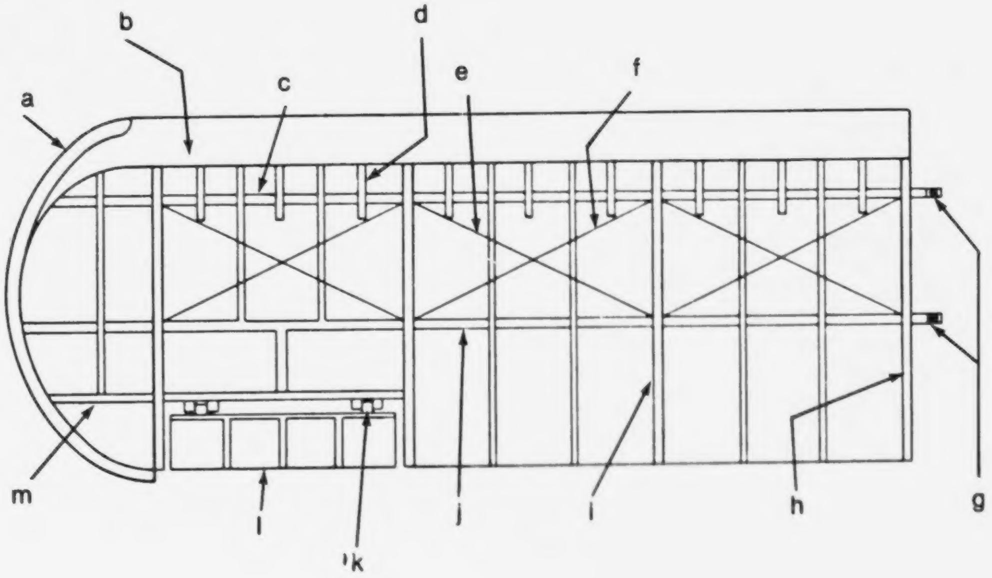
d. ______________________



e. ______________________

4. Label structural parts of the following metal and wooden aircraft wings. Write the correct names in the blanks.

Wooden wing



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

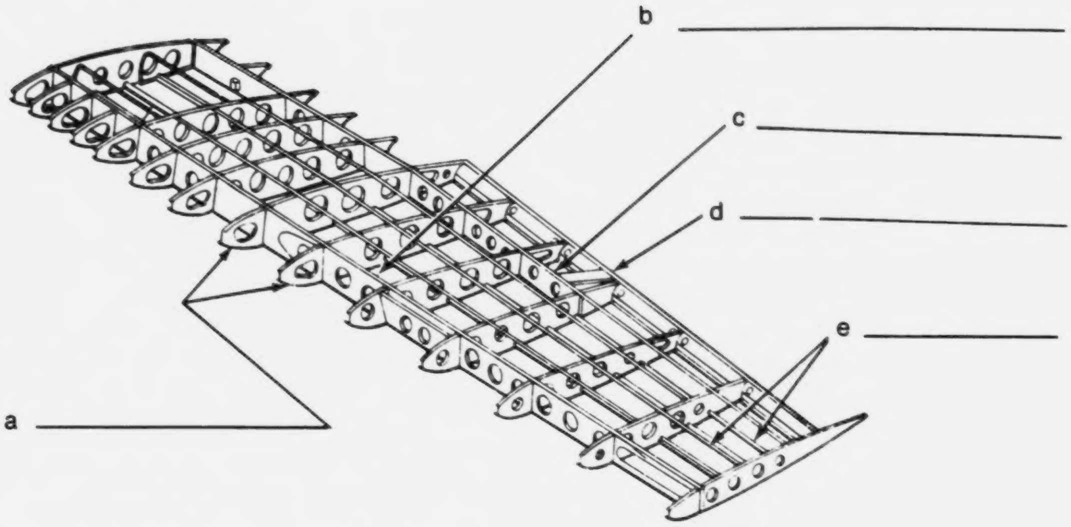
k. ______________________________

l. ______________________________

m. ______________________________

THEORY TEST

Metal wing



5. An aircraft wing is composed of a group of unique parts which are fastened together to create an extremely strong and aerodynamic structure. Below is a list of the individual parts found in a number of common wings. State the purpose of the following specific parts of the aircraft wing.

   a. Rib —

   b. Spar —

   c. Skin —

   d. Nose rib —

   e. Drag wire —

f. Antidrag wire — ______________________________

____

g. Compression rib — ______________________________

____

h. Wing attach fittings — ______________________________

____

i. Aileron spar — ______________________________

____

6. Select statements related to construction and operational characteristics of wings and their parts. Circle the numbers before the correct answers.

a. The cantilever wing uses

1) external wood bracing

2) ribs as the principal structural members

3) no external bracing

4) the skin to carry most of the load to wing butt

b. The I-beam wooden spar is routed to

1) improve shape

2) increase strength

3) remove imperfections

4) reduce weight

c. When an aircraft's wing is moved rapidly through the air, it produces

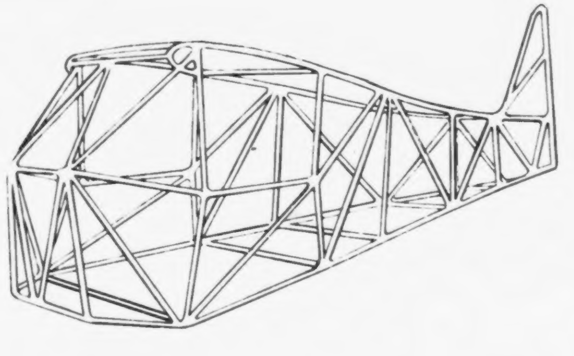
1) thrust

2) water

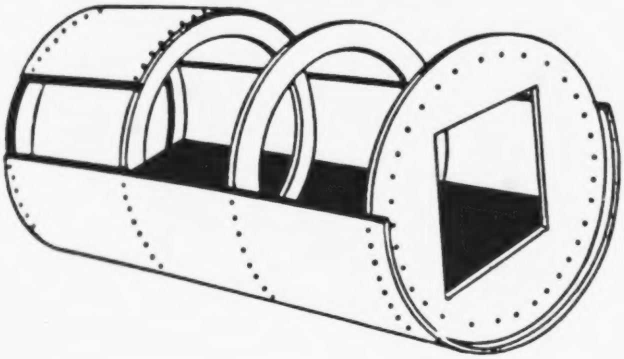
3) gravity

4) lift

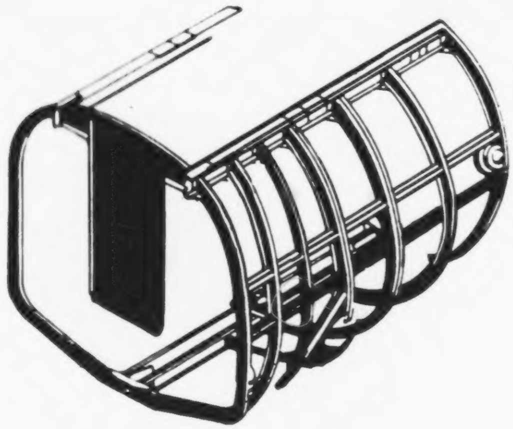
7. Label the three types of fuselage construction. Write the correct names in the blanks.



a. ______________________________



b. ______________________________



c. ______________________________

f. Antidrag wire — ____________________

____

g. Compression rib — ____________________

____

h. Wing attach fittings — ____________________

____

i. Aileron spar — ____________________

____

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3) gravity

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THEORY TEST

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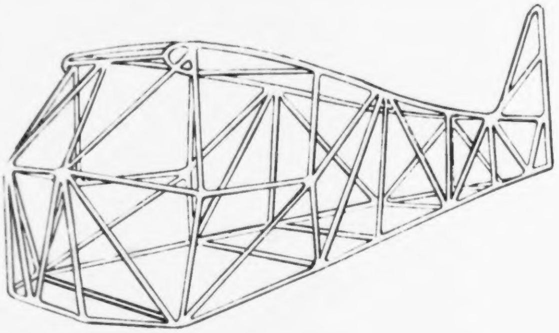
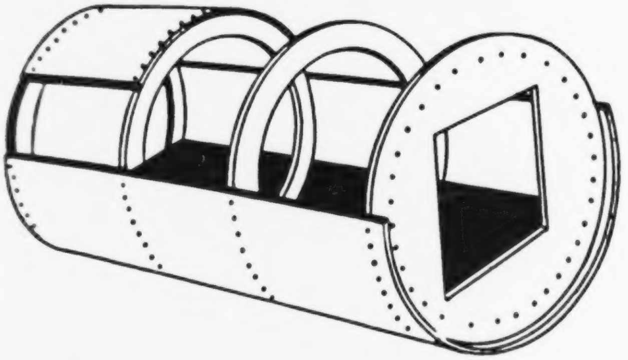
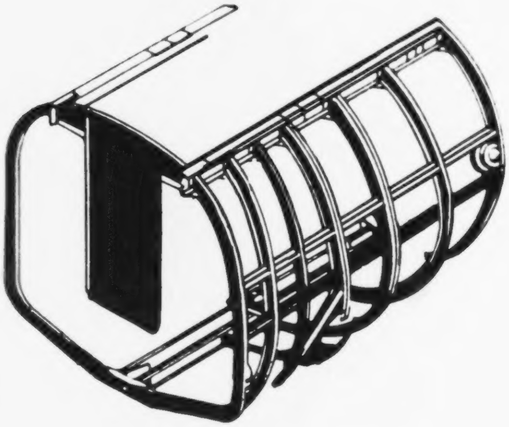


a. ______________________________



b. ______________________________

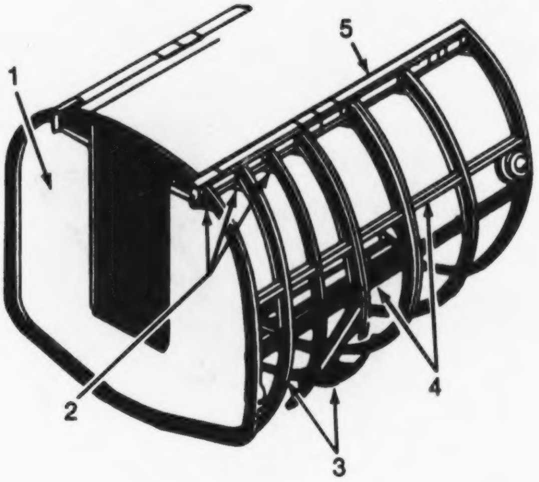


c. ______________________________

THEORY TEST

8. Label components of an aircraft empennage and fuselage. Write the correct names in the blanks.

a.

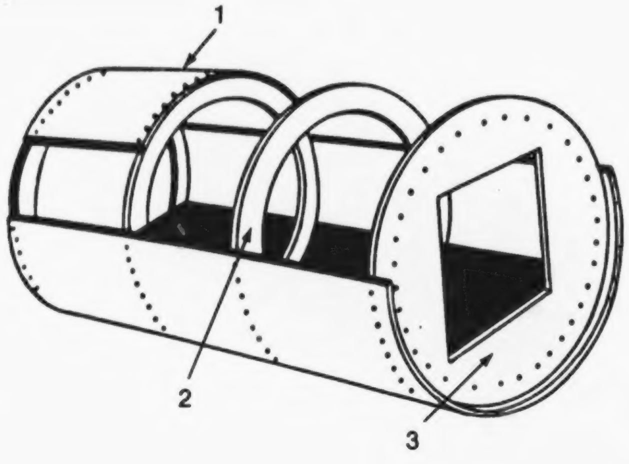


1) ______________________________ 4) ______________________________

2) ______________________________ 5) ______________________________

3) ______________________________

b.

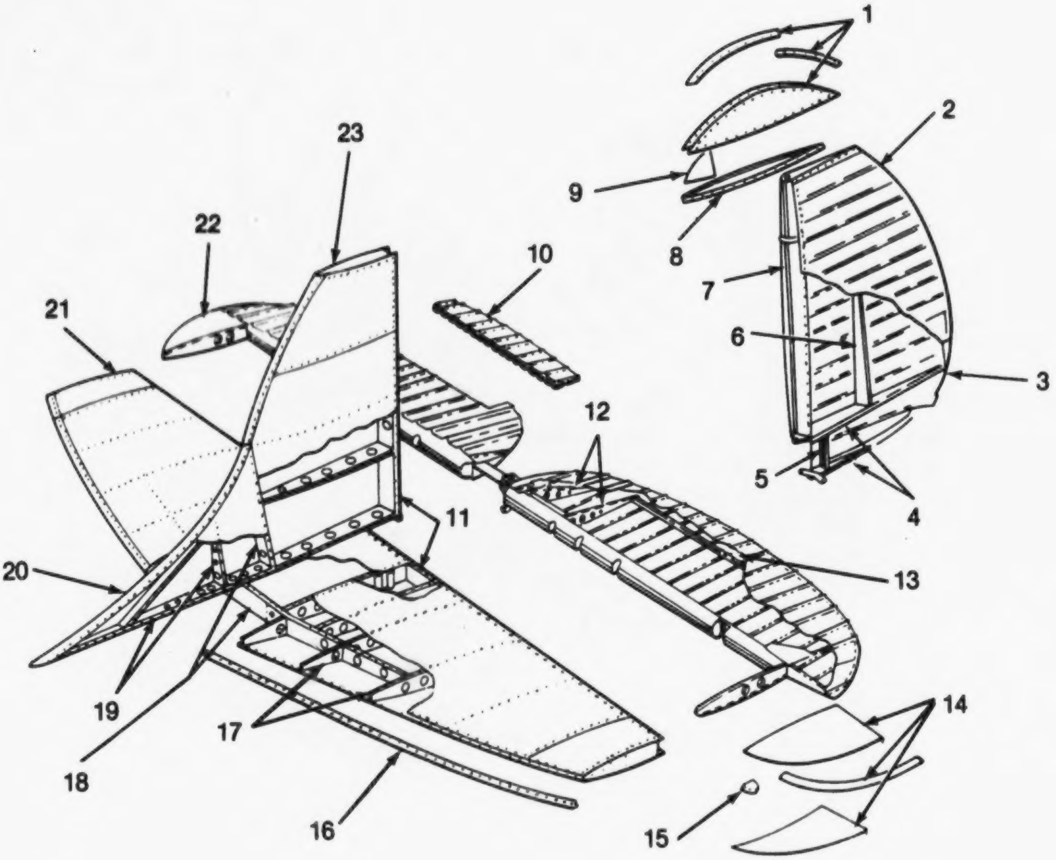


1) ______________________________ 3) ______________________________

2) ______________________________

66

c.


1
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16
15

THEORY TEST

1) ____________________ 13) ____________________

2) ____________________ 14) ____________________

3) ____________________ 15) ____________________

4) ____________________ 16) ____________________

5) ____________________ 17) ____________________

6) ____________________ 18) ____________________

7) ____________________ 19) ____________________

8) ____________________ 20) ____________________

9) ____________________ 21) ____________________

10) ____________________ 22) ____________________

11) ____________________ 23) ____________________

12) ____________________

9. The following statements relate to the construction, appearance, aerodynamics, and control surfaces of the empennage. Select true statements related to the empennage and its parts. Write an "X" in the blanks before the correct answers.

_____a. The empennage of an airplane is designed to provide a means to control the aircraft and serves no other purpose

_____b. The major parts of the empennage are the tail cone, vertical stabilizer, rudder, horizontal stabilizer, elevator, and applicable auxiliary tabs

_____c. Longitudinal stability and control are provided by the horizontal surfaces, while directional stability and control are provided by vertical surfaces

_____d. The vertical fin is swept back to increase the effective aerodynamic arm by moving the center of its area as far back from the vertical axis of the airplane as practical

_____e. A stabilizer is an all-movable tail which has a full-length balance tab attached to its trailing edge

_____f. The T-tail configuration is helpful on some aircraft because it moves the horizontal surfaces outside the turbulence created by the wing

_____g. The V-tail with its two surfaces performs the same function as the conventional tail

THEORY TEST

10. A fuselage is the body of the aircraft to which the wings, empennage, powerplant, and landing gear attach. Maximum strength and minimum weight are design parameters for fuselage construction. Select true statements related to fuselage structures and their parts. Write an "X" in the blanks before the correct answers.

_____a. The truss and stressed-skin type of structures are the two major types of fuselage construction

_____b. The Warren truss is a fuselage structure which includes vertical struts as well as diagonal struts

_____c. A monocoque fuselage does not have the longerons and stringers which are found in the semi-monocoque fuselage

_____d. Primary bending loads are carried by the stringers

_____e. Vertical structural members are referred to as bulkheads, frames, and formers

_____f. Stringers and longerons help prevent tension and compression from bending the fuselage

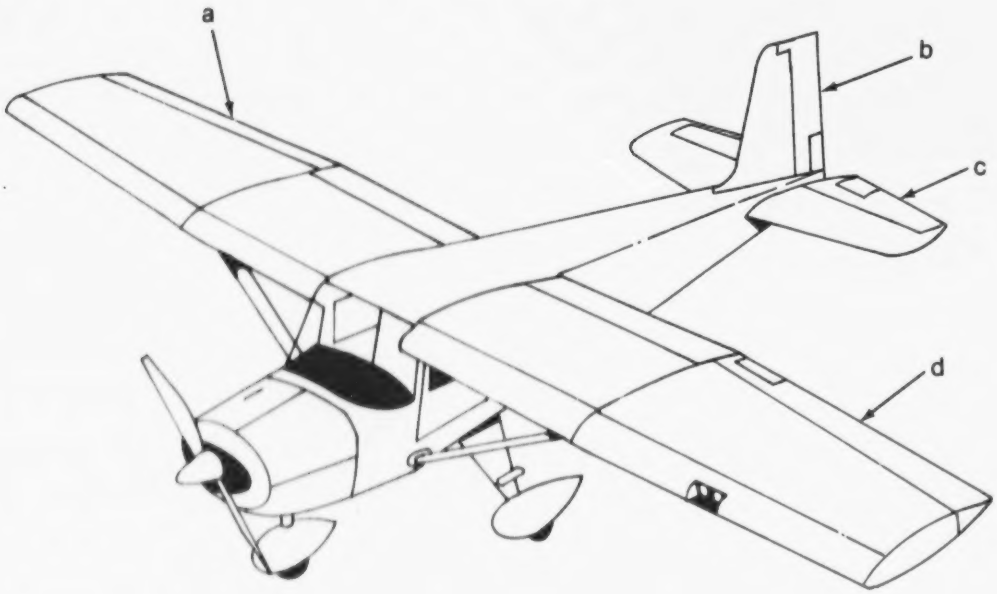
_____g. The bracing between longerons is often referred to as spider members

_____h. Semi-monocoque fuselages derive a portion of their strength from bulkheads and longerons

_____i. Monocoque fuselages derive their principal strength from the actual covering, metal or plywood

THEORY TEST

11. An airplane uses several movable primary control surfaces to move it around its three axes. Label aircraft primary control surfaces. Write the correct names in the blanks.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

12. Auxiliary surfaces are designed to aid the pilot in flying the aircraft and maintaining control. For each operational description given below, select the corresponding auxiliary surface. Write the correct numbers in the blanks.

______a. This surface rotates around a hinge located at its leading edge and is lowered to a position of 10, 20, 30, or 40 degrees deflection

______b. This surface rides out of the trailing edge of the wing on tracks, and when fully lowered, increases both the camber and the area of the wing

______c. This surface extends by means of a jackscrew and hinged linkage until it is positioned ahead of the wing's leading edge

______d. This surface rotates around a hinge located on the trailing edge of the elevator and moves in the opposite direction of the primary control surface; it is actuated mechanically by a jackscrew and connected to the control surface

______e. This surface moves in the opposite direction of the control surface; the linkage is attached to a fixed structure of the aircraft and can be adjusted by a jackscrew

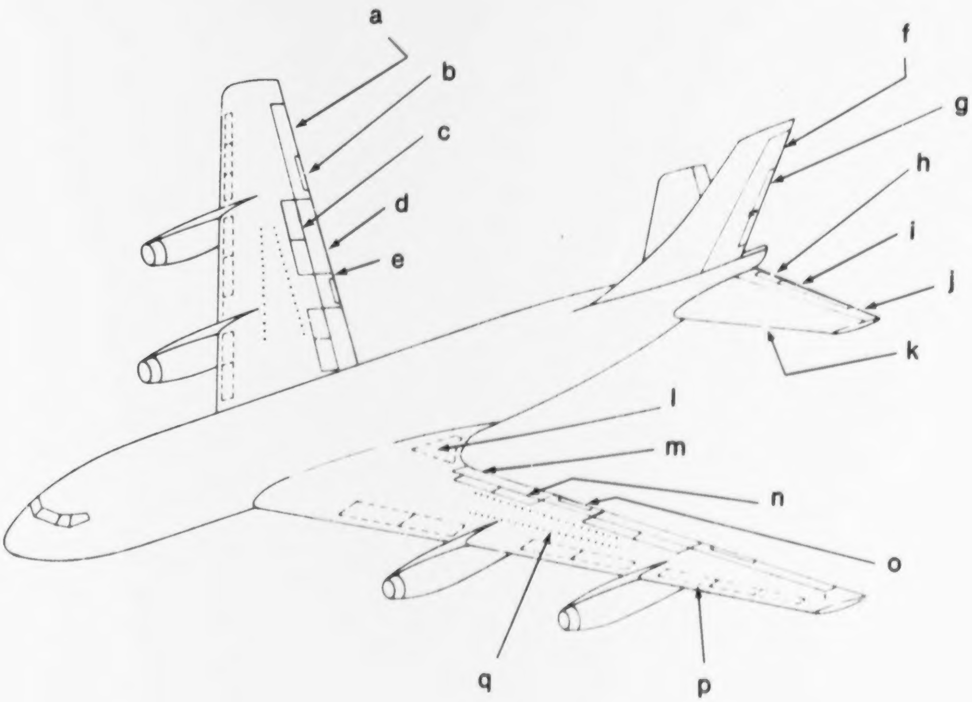
______f. This surface is deflected by an actuator connected to the fixed structure and moves in the opposite direction as the control surface

______g. This surface moves in the same direction as the control surface; it is actuated by a rod which has an adjustable attach point on the fixed structure

1. Plain flap
2. Anti-servo tab
3. Kreuger-type leading edge flap
4. Balance tab
5. Fowler flap
6. Servo tab
7. Adjustable trim tab

THEORY TEST

13. An airplane uses numerous auxiliary surfaces and devices to supplement lift, to create drag, to reduce control pressures, and for a variety of other aerodynamic functions. Label jet airliner primary and auxiliary control surfaces. Write the correct names in the blanks.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

l. ______________________

m. ______________________

n. ______________________

o. ______________________

p. ______________________

q. ______________________

THEORY TEST

14. Select statements related to the aerodynamics and construction of control surfaces, auxiliary surfaces, and auxiliary devices. Circle the numbers before the correct answers.

    a. An airplane moves about its longitudinal axis by using its

        1) elevator
        2) rudder
        3) flaps
        4) ailerons

    b. The rudder rotates an airplane about its

        1) vertical axis
        2) longitudinal axis
        3) vector lift line
        4) pitch axis

    c. Some large airplanes use two sets of ailerons on each wing. The inboard set is used for control at

        1) stall speed
        2) high speed
        3) low speed
        4) taxi speed

    d. Pairs of small, low-aspect-ratio airfoil sections mounted on the upper surface of a wing to pull high energy down onto the surface to prevent shock-induced separation are called

        1) winglets
        2) variometric inducers
        3) vortex generators
        4) vectored impulse airfoils

e. A deflection of more than 20 degrees of flaps usually produces

   1) equal amounts of drag and lift

   2) more lift than drag

   3) no increase in drag

   4) more drag than lift

15. There are several different types of landing gear that support an aircraft while it is not flying. Discuss common types of structures that support an aircraft on the ground by answering the following questions.

a. What are two types of skis that may be used on an airplane?

   1)

   2)

b. What is the primary disadvantage of the tailwheel type of landing gear?

c. Why do some airplanes have the landing gear retract into the structure when the airplane is flying?

d. What are two disadvantages of a tricycle landing gear for operation from rough and unimproved surfaces?

   1)

   2)

THEORY TEST

16. Powerplants are required to supply the necessary thrust for sustained flight. This creates construction characteristics which vary in conjunction with design goals. Discuss the structures used to house aircraft powerplants by answering the following questions.

    a. What is the advantage of a twin-engine having center-line thrust over one with the engines mounted on the wings?

    b. Why is it important that modern piston engines be installed in tight-fitting cowlings?

    c. What are the two most common locations for mounting jet engines on an airplane?

    1)

    2)

    d. What type of drag is created by the landing gear extending into the airstream?

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IDENTIFY AERODYNAMIC AND CONSTRUCTION CHARACTERISTICS OF AIRCRAFT STRUCTURES
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ANSWERS TO THEORY TEST

1. a. 5
b. 7
c. 3
d. 1
e. 8
f. 6
g. 2
h. 4
i. 9
j. 10
k. 16
l. 19
m. 11
n. 18
o. 12
p. 17
q. 14
r. 15
s. 13
t. 21
u. 20
v. 22
w. 23
x. 28
y. 24
z. 27
aa. 26
bb. 25

2. a. 3
b. 1
c. 2
d. 4
e. 5
f. 1
g. 4
h. 3
i. 2
j. 5

3. **Wooden spars**

a. Truss
b. Hollow
c. I-beam, built-up
d. Box
e. I-beam, externally routed
f. Rectangular

Metal spars

a. Tubular
b. I-beam, double-web
c. I-beam, built-up
d. I-beam, extruded, lightening holes
e. I-beam, built-up, fail-safe construction

4. **Wooden wing**

a. Wing tip
b. Leading edge strip
c. Front spar
d. Nose rib or false rib
e. Antidrag wire or tie rod
f. Drag wire or tie rod
g. Wing attach fittings
h. Wing butt rib
i. Wing rib or plain rib
j. Rear spar
k. Aileron hinge
l. Aileron
m. False spar or aileron spar

Metal wing

a. Ribs
b. Front spar
c. Rear spar
d. Auxiliary spar
e. Stringers

ANSWERS TO THEORY TEST

5. a. Gives the wing its cambered shape and transmits stresses from the skin and stringers to spar
   b. The principal structural member of the wing; transmits stress from the wing to the fuselage
   c. Distributes and carries wing stresses
   d. Gives the wing leading edge area the necessary curvature and support
   e. Resists the backward forces in the chord direction
   f. Resists the forward forces in the chord direction
   g. Designed to withstand compression loads
   h. Provides a means for attaching wings to the fuselage
   i. Provides a hinge attachment point for the aileron

6. a. 3
   b. 4
   c. 4

7. a. Truss
   b. Monocoque
   c. Semi-monocoque

8. a. 1) Bulkhead
      2) Gussets
      3) Frames
      4) Stringers
      5) Longeron

   b. 1) Skin
      2) Former
      3) Bulkhead

   c. 1) Tip skins
      2) Rudder
      3) Trim tab
      4) Ribs
      5) Channel
      6) Auxiliary spar
      7) Main spar
      8) Tip rib
      9) Balance weight
      10) Trim tab
      11) Rear spar
      12) Ribs
      13) Auxiliary spar
      14) Tip skins
      15) Balance weight
      16) Leading edge skin
      17) Ribs
      18) Front spar
      19) Dorsal ribs
      20) Dorsal fin
      21) Horizontal stabilizer
      22) Elevator
      23) Vertical stabilizer

9. b, c, d, f, g

10. a, c, e, f, h, i

ANSWERS TO THEORY TEST

11. a. Right aileron
    b. Rudder
    c. Elevator
    d. Left Aileron

12. a. 1
    b. 5
    c. 3
    d. 7
    e. 4
    f. 6
    g. 2

13. a. Low speed aileron
    b. Aileron balance tab
    c. Outboard spoilers
    d. Outboard flap
    e. High speed aileron
    f. Rudder
    g. Rudder control tab
    h. Stabilizer actuated elevator tab
    i. Elevator control tab
    j. Elevator
    k. Stabilizer
    l. Fillet flap
    m. Inboard flap
    n. Inboard spoilers
    o. Control tab
    p. Leading edge flaps
    q. Vortex generators

14. a. 4
    b. 1
    c. 2
    d. 3
    e. 4

15. a. 1) Wheel replacement ski
       2) Retractable ski

    b. The primary disadvantage of a tailwheel-type landing gear is the tendency of the airplane to ground loop, caused by the center of gravity being behind the contact point of the main wheels.

    c. Retracting the landing gear into the structure reduces the parasite drag

    d. 1) The heavy structure required for the nose wheel
       2) The additional speed needed to lift the nose wheel free of the rough ground

ANSWERS TO THEORY TEST

16. a. An airplane having center-line thrust does not have asymmetrical thrust when it is operating on one engine

    b. The tight-fitting cowling around the engine provides pressure cooling as air is forced through the fins on the cylinders by differential pressure

    c. 1) In or on the empennage
       2) In pods below the wing

    d. Parasite drag

MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

AIRFRAME

A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

INSPECT WOODEN STRUCTURES

A201-B

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MODULE CONTENTS

A. Introduction and Module Objective

B. Specific Objectives

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  2. TM #2 — Splayed Patch
  3. TM #3 — Repair of Wooden Ribs
  4. TM #4 — Repair of Wooden Ribs (Continued)
  5. TM #5 — Repair of Wooden Ribs (Continued)
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I. Project Guide #1 — Inspect a Wooden Structure

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K. Answers to Theory Test

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INTRODUCTION

Wood was used in early aircraft structures because of its availability, workability, high strength-to-weight ratio, and relatively low cost. Wood is not used extensively today because of its limited availability and its low resistance to fire. Because of its organic origins, wood also has a slightly shorter life than metallic or composite structures.

Although wood has disappeared somewhat from aviation, wood is still used in structures of a few commercial designs and many experimentals. The aviation maintenance technician must know how to inspect and repair these wooden structures to ensure their airworthiness.

MODULE OBJECTIVE

After completion of this module, you will be able to discuss approved repair procedures and perform routine inspections on wooden structures. Your competency will be evaluated by completing workbook assignments, project guide, and by scoring a minimum of 85 percent on the module theory test.

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SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

1. Match terms related to inspection and repair of wooden structures to their correct definitions. (1)	Technical Supplement #1	
2. Select true statements related to forms of wood commonly used in aircraft. (1)	EA-ITP-AB	34-35
	AC 65-15A	228-229
	AC 43.13-1A&2A	1-2
	EA-ITP-AW	1:I:9
	Workbook Supplement #1	
3. Distinguish between defects which are permitted and defects which are not permitted in woods used for aircraft repair. (2)	AC 65-15A	229-230
	AC 43.13-1A&2A	3
	Workbook Supplement #1	
4. Match terms related to synthetic resin glues and their applications to their correct definitions. (1)	AC 65-15A	231
5. Select statements related to gluing processes. (1)	EA-ITP-AB	35-37
	AC 65-15A	230-233
	AC 43.13-1A&2A	3-5
	EA-ITP-AW	1:I:9
6. Discuss the fabrication of a spliced joint used to repair a structural member. (2)	AC 65-15A	234-235
	AC 43.13-1A&2A	5-6
	Workbook Supplement #2	
7. Select statements related to plywood skin repairs. (1)	EA-ITP-AB	43-49
	AC 65-15A	235-242
	AC 43.13-1A&2A	9-23
	EA-ITP-AW	1:I:10
8. Arrange in proper order the steps for making an oval or round patch for a plywood skin. (1)	AC 65-15A	238-239
	Workbook Supplement #2	
9. Use a detailed drawing to determine dimensions and procedures for a common wooden structure repair. (2)	EA-ITP-AB	37-43
	AC 65-15A	236-246
	EA-ITP-AW	1:I:10
10. Select statements related to spar, rib, and bolt/bushing hole repairs in wooden structures. (1)	EA-ITP-AB	37-43
	AC 65-15A	242-246
	AC 43.13-1A&2A	1, 6-8
	Workbook Supplement #3	

SPECIFIC OBJECTIVES

11. Discuss factors related to wood condition inspection, glued joint inspection, and procedures used when inspecting wooden structures. (2)	EA-ITP-AB	33-34
	AC 65-15A	224-228
	AC 43.13-1A&2A	3
	Workbook Supplement #3	
12. Inspect a wooden structure. (2)	Project Guide #1	

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INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

I. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

Estimated Teaching Time		Theory	Lab
Objective 1	Explain the terms related to wooden structure inspection and repair. Have examples of these items for the students to examine. Examples are particularly useful to illustrate terms such as *decay*, *water penetration*, *plywood*, *laminated wood*, and *solid wood*. Have students review Technical Information Supplement #1.		
Objectives 2-3	Discuss materials used in wooden aircraft structures, including types of woods used, comparisons of the applicability of these woods, and defects found in wood which are permitted or are not permitted. Use Instructional Supplement #1 to provide additional information about wood. Explain that the technician's responsibility is to make sure that the wood used to repair aircraft structures meets all necessary requirements. Have students complete Workbook Supplement #1.		
Objective 4	Explain the terms related to synthetic glues and their applications. Show examples of the components which are combined to create resin-type glues.		

INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

Estimated Teaching Time		Theory	Lab
Objective 5	Explain the basic gluing process used to join wood. Prepare the materials ahead of time to create a scarf-type splice. Demonstrate the proper procedures used in mixing a resin-type glue. Use this glue to join the pieces used to fabricate the scarf splice. Emphasize in your demonstration the proper way to apply pressure to the joint. After your splice is complete, join two pieces (1 inch wide by 2 inches long) of the same material (type and thickness) in a simple lap joint (overlap the pieces $^{3}/_{8}$ inch). Allow this test sample to cure overnight, then demonstrate testing the joint to ensure proper gluing.		
Objective 6	Explain how the scarf splice is prepared. Use Transparency Master #1. Have available the materials and tools needed to simulate preparing a scarf cut. Have the students complete question A in Workbook Supplement #2.		
Objective 7	Discuss plywood skin repairs. Use Transparency Masters #2-#6. Show examples of a plug patch, a splayed patch, and a scarf patch. Explain how the applicability of a specific repair is determined.		
Objective 8	Explain how a circular plug patch repair is made to a plywood skin, emphasizing the order of repair operations. Show examples of the plug patch repair at various stages in the fabrication process. Have students complete question B in Workbook Supplement #2.		
Objective 9	Explain how to interpret a detailed drawing to determine the required dimensions of a repair. Give the students examples of structural damage and component dimensions, and allow them to determine the dimensions of the repair. Have students complete EA-ITP-AW 1:I:9-10.		

INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

Estimated Teaching Time		Theory	Lab
Objective 10	Discuss repairs which are made on spars, ribs, and bolt/bushing holes. Have examples of these repairs for the students to examine. Use Transparency Master #7 to show the tapering of face plates as one way that shrinkage can be prevented from ruining a glued joint. Have students review information provided by a manufacturer pertaining to a repair on a compression rib.		
Objective 11	Discuss the procedures involved in performing an inspection of a wooden structure. Explain how to determine wood condition and glued joint integrity. Use Transparency Masters #8 and #9. Have students complete Workbook Supplement #3.		
Objective 12	Discuss Project Guide #1 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. An unairworthy wooden wing or fuselage which has the plywood skin partially removed will be needed for this project. Have students complete the project. Review the project in class after all students have completed.		

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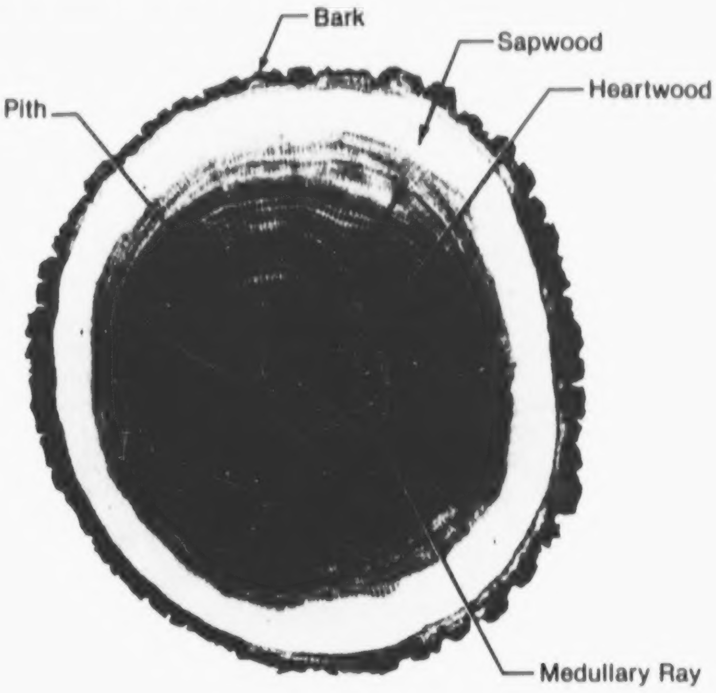
INSTRUCTIONAL SUPPLEMENT #1 — Characteristics of Wood

1. **Tree structure.**—*a.* Examination of the cross section of a log (Figure A) discloses four distinct regions or sections: the bark, the sapwood (light-colored layer next to the bark), the heartwood (darker wood inside the sapwood), and the pith (small, soft core of the tree). As a general rule, the sapwood is lighter in color than the heartwood. However, in spruce, basswood, and others, there is very little if any difference between the color of the heartwood and the sapwood. After timber is seasoned, the heartwood is usually more resistant to decay, stain, mold, and to the attack of certain insects, than is the sapwood; whereas, in the living tree the opposite is true.

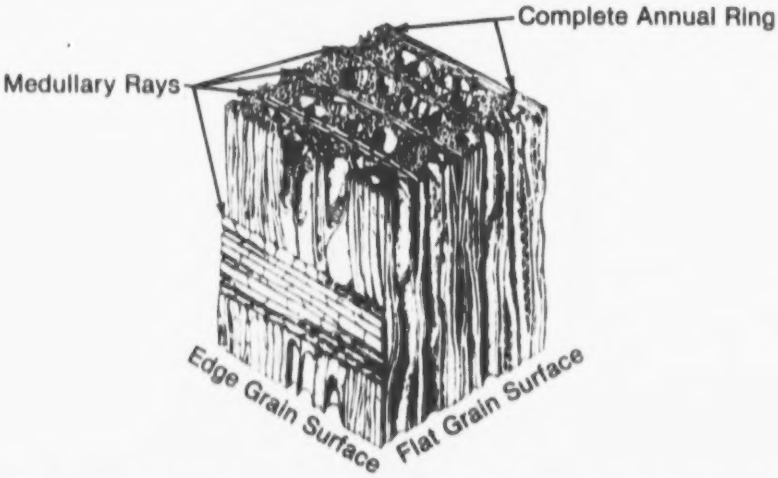
b. The bark serves as a protective covering for the tree. The cells of the sapwood function mainly in the movement and storage of food. Some of these cells are alive but most of them are dead, acting only as passages for sap and adding to the strength of the trunk. The cells of the heartwood are dead and function only in supplying strength to the trunk.

FIGURE A: Cross section of a log



2. **Classification.**—Woods are generally grouped as hardwoods or softwoods. Hardwoods come from broadleafed trees and include ash, birch, basswood, mahogany, maple, walnut, etc. Softwoods come from trees with needlelike or scalelike leaves (evergreens), commonly known as conifers, and include fir, pine, cypress, and spruce. In some instances the terms are not descriptively exact since yellow pine, generally classified as a softwood, is in reality harder than basswood, which is classified as a hardwood. However, as a result of long usage, the terms have become definitely established.

FIGURE B: Magnified view of hardwood cube



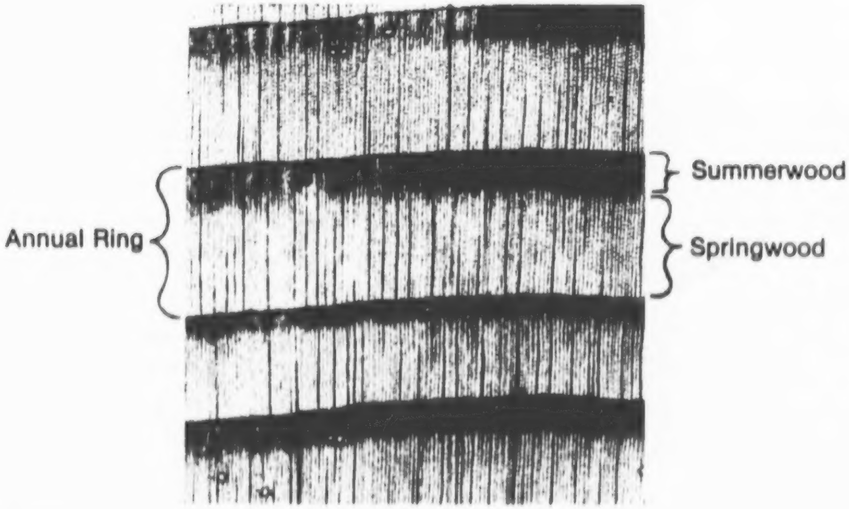
3. **Cellular structure.**—*a.* Figure B shows the magnified cell structure of a cube of hardwood. Wood is composed of many different sizes and shapes of cells all tightly grown together. The substance of which these cells are made is substantially the same in all species of woods, but the size and arrangement of the cells vary greatly with the different woods. It is this difference in the size, thickness of cell walls, and arrangement of cells that accounts for the great variation in the weight and strength of woods.

b. (1) The hardwoods differ from the softwoods as a class in the presence of larger cells, constituting pores, scattered among the smaller ones which are mostly fibers. In many hardwoods the pores may be seen distinctly without magnification, as small holes on smoothly cut cross sections and as fine grooves on planed longitudinal surfaces.

(2) In softwoods, the bulk of the wood is composed of fibrous cells which may be seen on a smoothly cut magnified cross section.

4. **Medullary rays.**—Medullary rays, also known as pith rays, are rows of cells which extend radially from the center of the tree (see Figures A and B). They vary greatly in size, being so small in many woods as to be invisible without magnification. In oak, however, they are very large and account for large silvery patches so characteristic of this wood when it is quarter-sawed.

FIGURE C: Magnified view of annual ring



5. **Springwood and summerwood.**—Each annual ring (Figure C) is composed of two regions or parts: the springwood and the summerwood. Springwood is the wood formed on the inner side of the annual ring during the early part of the growing season. It is usually more porous, softer, weaker, and especially in conifers, lighter in color than the summerwood, which is formed in the outer part of the annual ring during the latter part of the growing season. In some woods the distinction between these two parts of an annual ring is very clear, whereas in others the springwood merges into the summerwood with no distinct dividing line.

6. **Grain.**—*a.* The recommended usage of the term "grain" is that it be confined to describing the direction in which the fibers run, that is, straight, spiral, interlocked, wavy, or curly grain. However, the term is also loosely used to refer to annual rings as coarse, fine, even, edge, and flat grain; and to the relative size of pores and fibers as open grain and close grain.

b. Wood employed in aircraft construction is straight-grained within limits of deviation as set forth in the specification for the particular lumber used.

7. **Common defects in wood.**—Irregularities which occur in or on wood which may lower its strength are regarded as defects. Common defects in wood are described below.

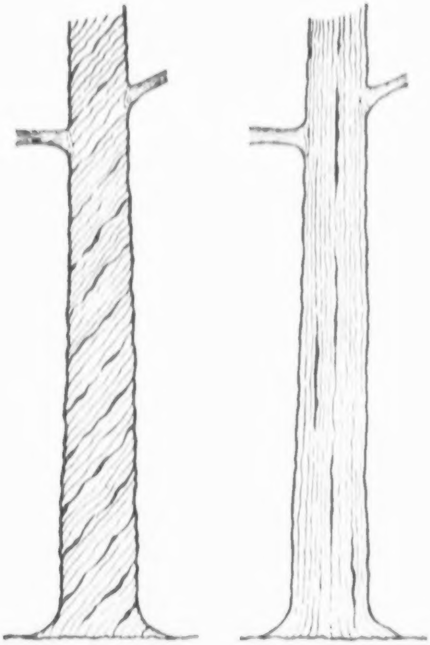
a. *Cross grain.*—Cross grain may be regarded as any deviation of the grain from parallelism with the axis of a piece of wood. It may be classified as spiral, diagonal, or a combination of both.

(1) *Spiral.—(a)* Spiral grain occurs when the fibers take a spiral course in the tree trunk, as if the tree had been twisted (Figure D1). On a truly tangential (plain-sawed or flat grain) surface (See Figure E) the oblique direction of the checks, resin ducts (brownish hairlike lines in softwoods), and pores (visible in many hardwoods) indicate the direction of the fibers. Normally, this direction is parallel to a line drawn through the apexes of the "flowers" formed by the annual rings on a plain-sawed surface; however, if spiral grain is present, the fibers run at an angle to this line. If sufficient pores, resin ducts, or checks are not visible, the direction of the grain can be determined by the direction in which free-flowing ink spreads or fibers pull up. The presence (but not the slope) of spiral grain is indicated on quarter-sawed faces when the planer tears out chips in such a way as to show that the grain runs into the piece instead of parallel to its axis.

(b) Spiral grain, when pronounced, is objectionable because it weakens the wood, tends to twist the lumber during seasoning, and usually produces a rough surface when quarter-sawed faces are planed against the grain.

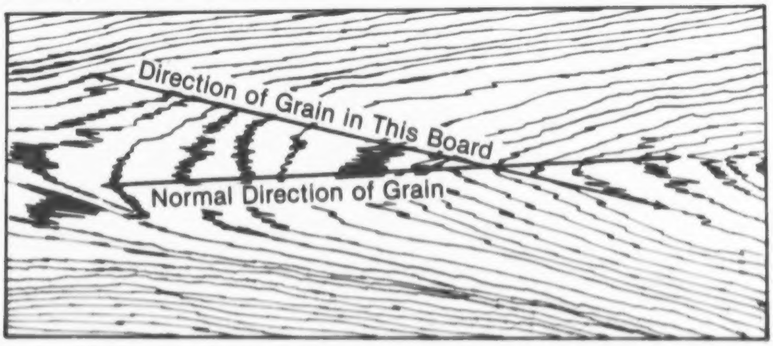
(2) *Diagonal.—(a)* Diagonal grain in lumber is a defect produced entirely by sawing and results when the direction of sawing is not parallel to the bark. Spiral grain is frequently confused with diagonal grain; however, there is no relationship between the two since spiral grain is a defect of growth. On a truly edge grain surface, diagonal grain is easily detected by the slope of the annual rings.

FIGURE D: Spiral and normal tree growth



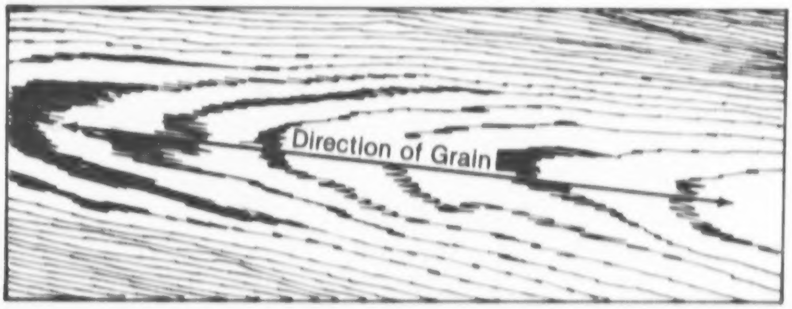
1. Spiral 2. Normal

FIGURE E: Spiral grain in lumber


Direction of Grain in This Board
Normal Direction of Grain

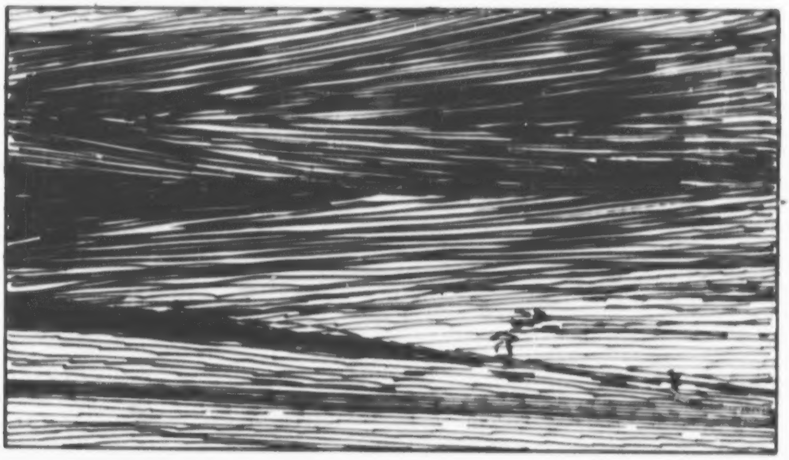
On the flat grain (plain-sawed) surface (Figure F), its presence (but not the slope) may be detected by a line drawn through the apexes of the "flowers."

FIGURE F: Diagonal grain in lumber


Direction of Grain

(b) Diagonal grain, when pronounced, is objectionable because of its weakening effect on lumber and the chipped appearance of the surface which results when planing the plain-sawed faces against the grain.

FIGURE G: Interlocked grain

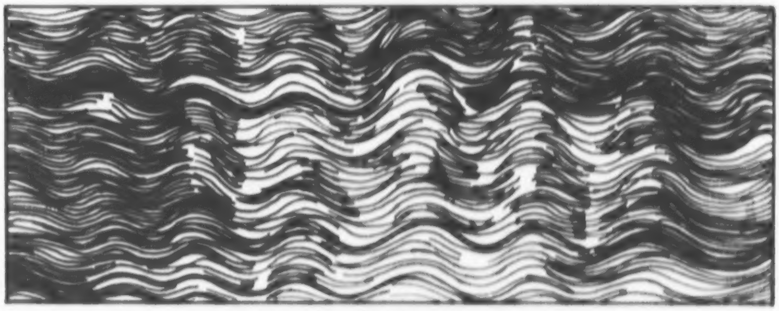


(3) *Interlocked.—(a)* Interlocked grain (See Figure G) is produced when the fibers are inclined in one direction in a number of annual growth rings, then gradually reverse and are inclined in an opposite direction in succeeding growth rings, and then reverse again. Interlocked grain is confined largely to hardwoods, seldom being found in softwoods.

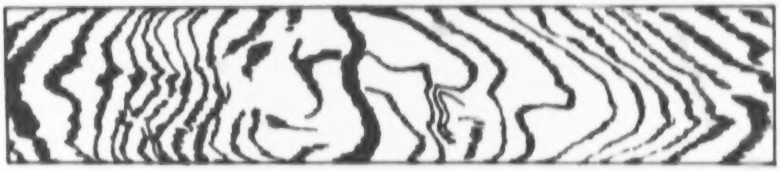
(b) Interlocked grain is a common cause of warping, especially in plain-sawed lumber, and causes difficulty in planing.

(4) *Wavy and curly.*—Wavy grain and curly grain result when the wood fibers assume contorted courses in parts of trees or throughout the whole trunk and branches. The contortions may be regular as in wavy grain (Figure H1), or very irregular as in curly grain (Figure H2).

FIGURE H: Wavy and curly grains



1. Wavy



2. Curly

b. *Knots.*—(1) A knot is the base of a limb embedded in the tree trunk. Normally, a knot starts at the pith and increases in diameter from the pith outward as long as the limb is alive. Occasionally it starts some distance from the pith. As long as the limb remains alive, its fibers interlace with those of the trunk, producing an intergrown knot. After the limb dies the wood formed in the trunk makes no further connection with it, but grows around it, producing an encased knot. When the dead limb breaks off, the stub heals over and the distortion of grain in successive growth layers lessens with increasing diameter of the trunk until, finally, clear wood with normal grain is produced.

(2) A sound, tight knot, solid across its face, is fully as hard as the surrounding wood, shows no sign of decay, and is so fixed by growth or position that it will firmly retain its place in the piece. A knot cut through transversely is known as a round knot (See Figure I); one cut through obliquely is known as an oval knot (See Figure J); and one cut through lengthwise is known as a spike knot (See Figure K).

INSTRUCTIONAL SUPPLEMENT #1

FIGURE I: Round knot

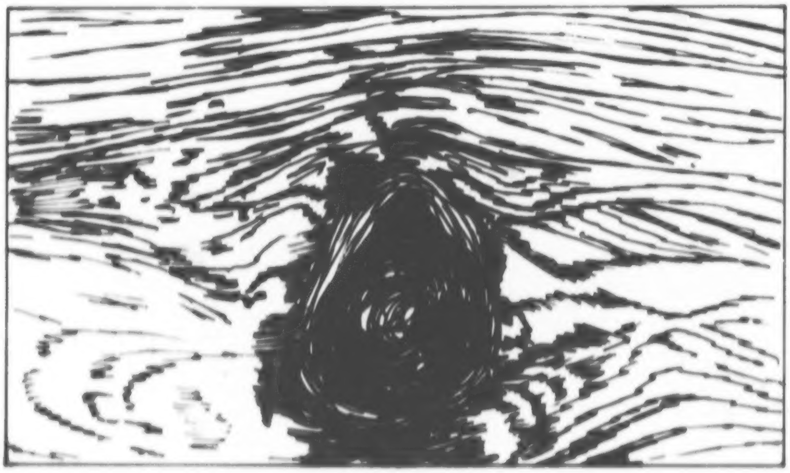


FIGURE J: Oval knot

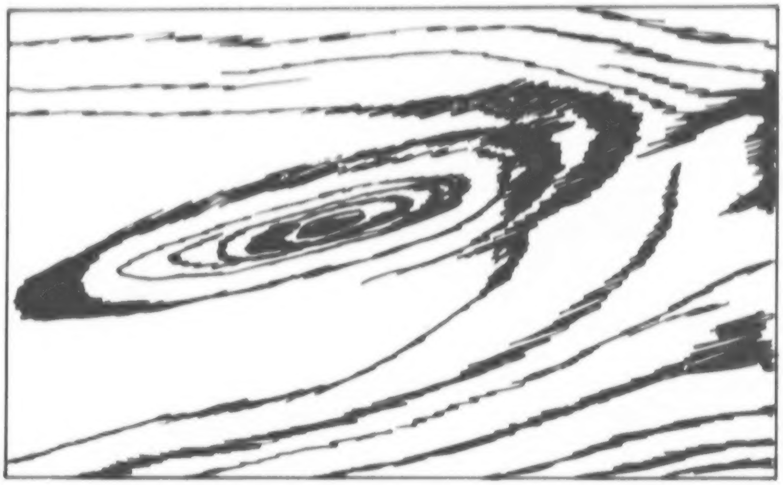
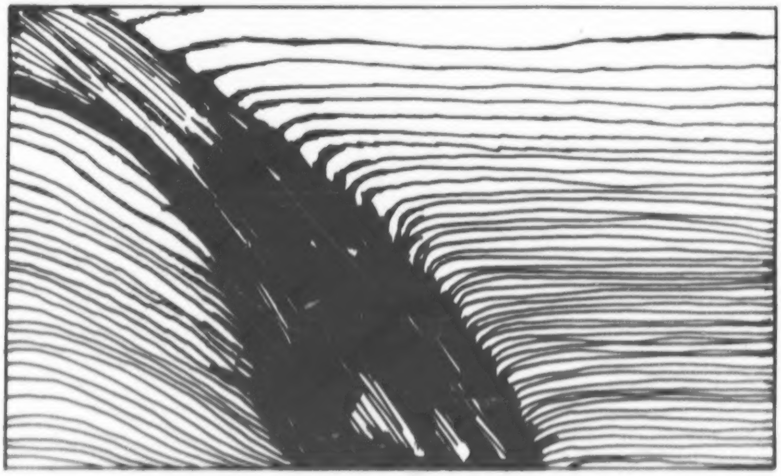


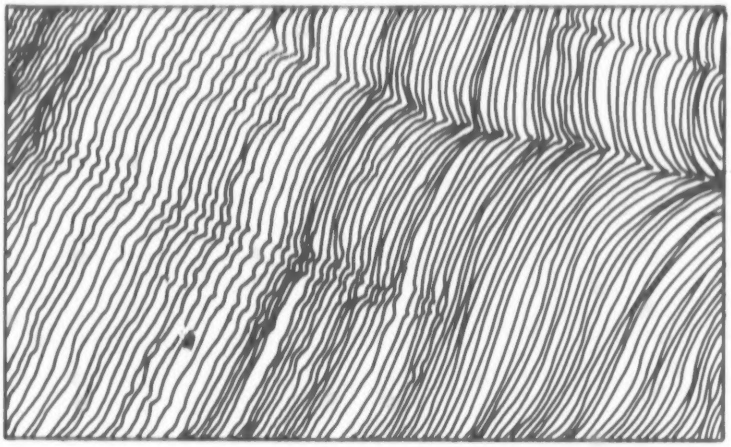
FIGURE K: Spike knot



(3) Knots are objectionable mainly because of the distortion and discontinuity (caused by encased knots) of the grain they produce thereby weakening the wood. Knots also cause irregular shrinkage and difficult working of lumber. Loose knots are likely to drop out and in resinous species pitch often exudes more freely from a knot than from the clear wood.

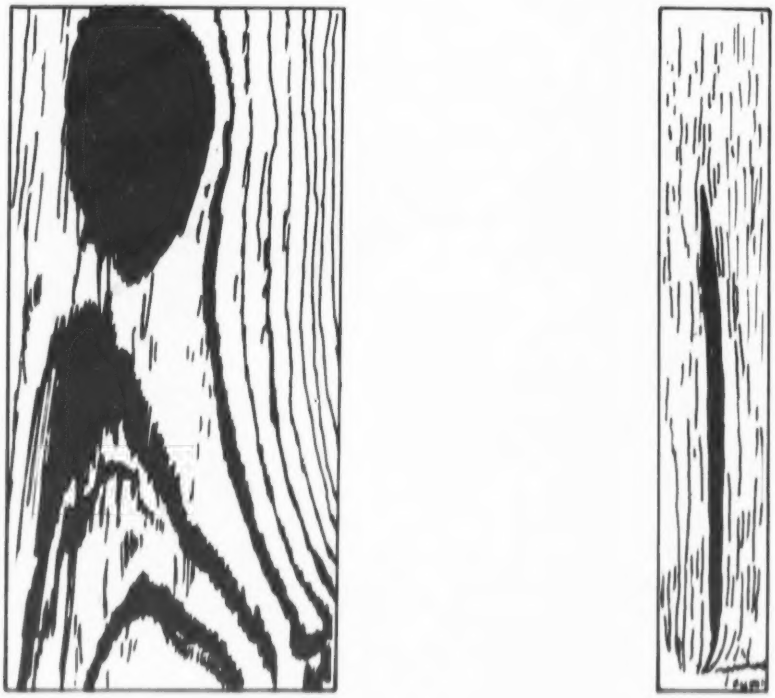
c. Indented growth rings.—In certain softwoods the annual rings as seen on a cross section, are sometimes successively indented along a radial line (Figure L). In a tangential plane, indented rings produce noticeable blemishes but cause no distortion of grain. The presence of indented rings is not regarded as serious in members of fair size or ordinary proportions.

FIGURE L: Indented growth rings



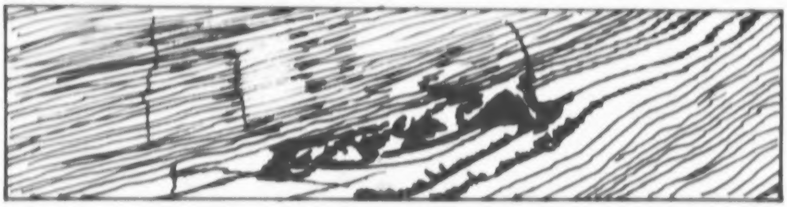
INSTRUCTIONAL SUPPLEMENT #1

FIGURE M: Pitch pocket



1. Cut Through Tangentially

2. Cut Through Radially

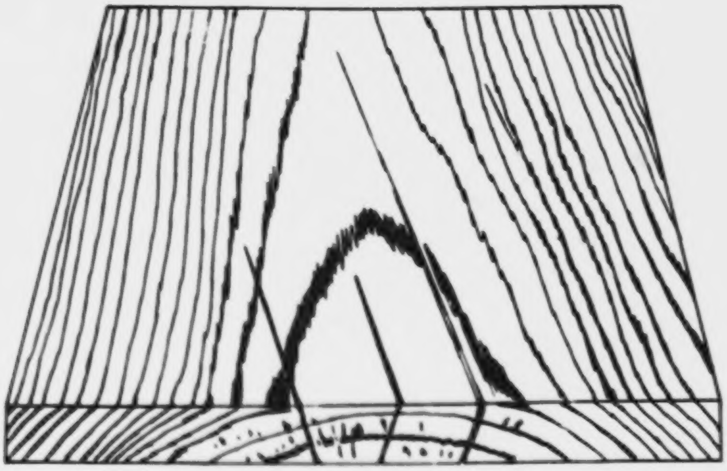


3. Cut Through Transversely

d. Pitch pockets.—(1) Pitch pockets (Figure M) are well-defined openings, usually longer than wide, between annual rings. They contain more or less free resin and occasionally contain bark.

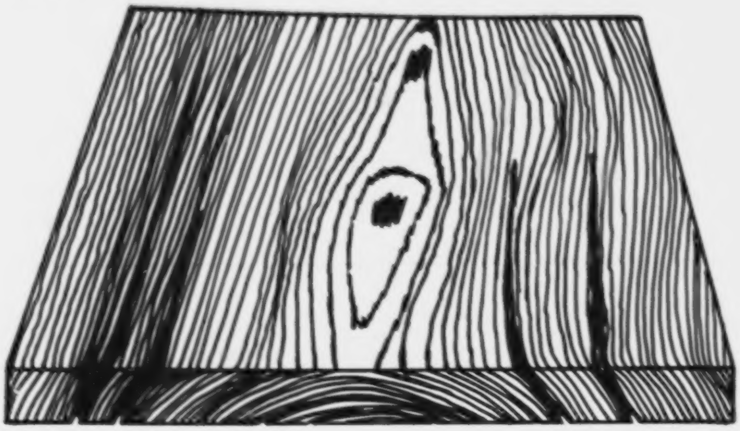
(2) Pitch pockets are objectionable because they may weaken small members and also may exude resin, especially when the wood becomes warm.

FIGURE N: Checks in lumber



e. Checks, shakes, and splits.—(1) *Causes.*—*(a)* A check (Figure N) is a longitudinal crack generally extending radially across the annual rings. Checks are usually caused by uneven shrinking in seasoning.

FIGURE O: Shakes in lumber



(b) A shake (Figure O) is a longitudinal crack extending, in general, between two annual rings. Shakes occur in green timber and may become accentuated in seasoning.

(c) A split is a longitudinal crack caused by rough handling or other artificially induced stresses. When splits take a radial or tangential course they are not readily distinguishable from checks or shakes.

(2) *Effects.*—Checks, shakes, or splits may seriously weaken members. The weakening influence of such defects is usually greater than the visible openings would indicate.

f. Stains and decays.—All woods, to a greater or less extent, are subject to stains and decays. Stains not associated with decay have, as a rule, little effect on strength; whereas decay affects the strength of wood even in the early stages. Many stains and decay are caused by fungi which grow in the wood. Development of fungi is dependent upon relatively high moisture content of wood, suitable temperature, an abundant supply of food substances, and a supply of oxygen. Lumber kept entirely dry (or entirely immersed in water) will not decay. Decay is prevented by proper kiln-drying or air-drying immediately after sawing, and thereafter by keeping it dry in storage. Keeping airplanes and parts in a dry place when not in use will usually prevent decay. Lack of air circulation when combined with high atmospheric humidity affords an ideal condition for the growth of wood-inhabiting fungi.

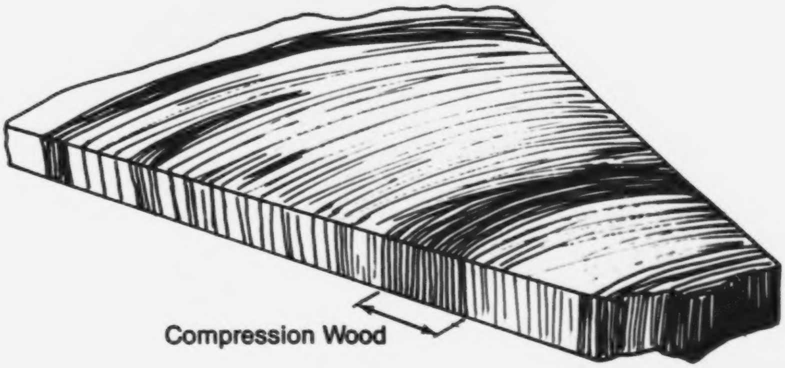
(1) *Stains.*—Stains in wood occur as specks, spots, streaks, or patches of varying intensities of color. The so-called "blue" stains, which vary from blue to bluish black and brown, are the most common, although various shades of yellow, orange, purple, and red are sometimes encountered.

(2) *Decay.*—*(a)* Incipient decay usually appears as a discoloration, in some cases pronounced, in others so faint as to be practically invisible. It rarely ends abruptly or evenly but usually fades out into one or more irregular streaks. Such streaks usually extend not more than three or four feet along the grain of the wood beyond the typical decay. The discoloration due to decay as observed on a cross section may be distinguished from the normally darker bands of heartwood by observing whether or not the darkening follows closely a definite group of annual rings; if so, the color variation is probably normal. If, on the contrary, the discoloration pattern is independent of the ring pattern, the color change may be a symptom of defect. Typical or late stages of decay are easily recognized because the wood has then undergone definite changes in color and properties. The rotted wood may be brown or white in color. There are also intermediate types between the white and brown rots.

(b) In the early stages of decay, the crushing strength parallel to the grain of the wood is affected but little, whereas the shock resistance is reduced markedly. In the final stages of the development of decay, little or no strength remains in the wood.

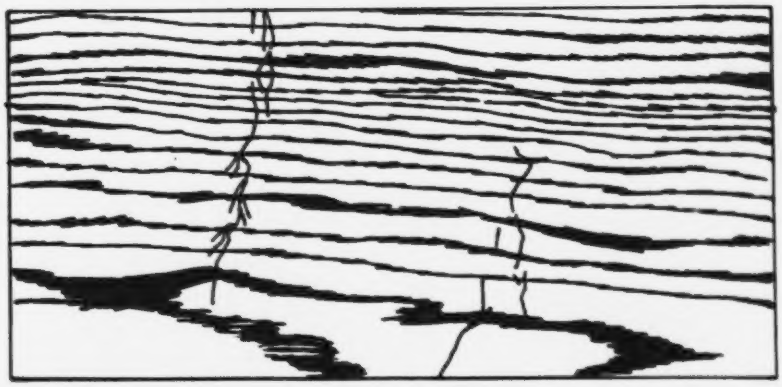
g. Compression wood.—Compression wood (See Figure P) is a type of abnormal growth frequently occurring in the under side of leaning trees and limbs of softwood species. In comparison to normal growth, it is distinguished by wider growth rings, usually eccentric, and includes what appears to be an exceptional proportion of summerwood growth. The contrast in color between springwood and summerwood, however, is usually less in compression wood than in normal wood. Compression wood has a high longitudinal shrinkage and is low in strength for its weight. When compression wood is present with normal wood, unequal endwise shrinkage causes bowing and crooking. Material containing compression wood is not generally permitted in aircraft construction.

FIGURE P: Compression wood



h. Compression failures.—Compression failures in wood (Figure Q) are caused by excessive bending of the standing tree from wind or snow, by felling trees across logs, rocks, or other objects, by rough handling of logs and sawed stock, and by excessive stresses in service. They appear as wrinkles or streaks substantially at right angles to the grain across the face of a board. Whereas some compression failures are so pronounced as to be unmistakable, others are difficult to detect. Tilting of the wood with respect to the line of vision or source of light may help to make compression failures visible.

FIGURE Q: Compression failure in lumber

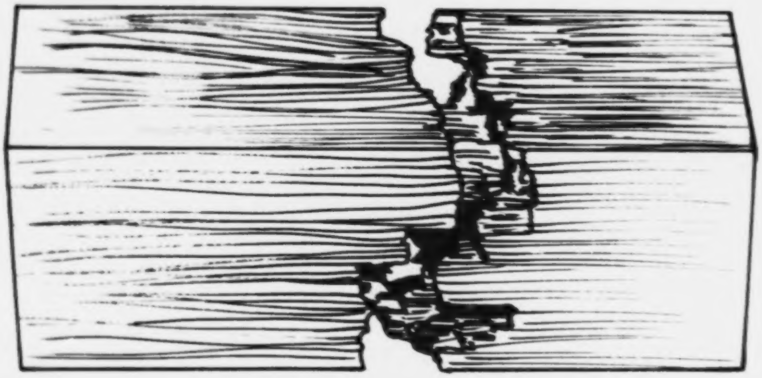


Even those failures not readily apparent to the eye may seriously reduce the bending strength of the wood and its shock-resisting ability. Wood containing compression failures is not permitted in aircraft construction.

i. Brashness.—The term "brash," frequently used interchangeably with the term "brittle," indicates a lack of toughness when used to describe wood or failures in wood. Brash wood (Figure R), upon being bent, usually fails suddenly and completely at small deflection, producing few or no splinters. Brash wood in the conifers is usually of very rapid growth, whereas in the hardwoods it is generally of very slow growth.

8. Factors affecting strength.—The most important factors which influence the strength of wood, other than defects, are the specific gravity, or density, and the moisture content. These factors cause variations in the properties of the same species as well as in different species of wood. However, in the finished stock these variations are largely eliminated by proper specifications and inspection.

FIGURE R: Brash wood



a. Specific gravity.—The best single criterion of the strength of wood other than mechanical test is its specific gravity or weight per unit volume, the weight being taken when the wood is completely dry. Determination of density, together with careful consideration of such defects as knots, cross grain, compression failures, compression wood, and decay, are now largely used as means of selecting airplane woods. Other factors which at times have some influence on selection are amount of summerwood, rate of growth, and region of growth. When wood is judged wholly on the basis of weight and appearance, some of the material accepted may be too low in strength, particularly tensile strength, and hence in shock resistance, to prove satisfactory. Such material is brash and is rejected whenever found. Frequently brash material is also of low density. It is material which is brash but still of satisfactory weight and good appearance which causes much trouble in airplane construction. Two of the most frequent causes of brashness in material of this kind are compression failures and decay, even in the very early stages before apparent to the eye. After some experience, a mechanic should be able to eliminate stock which is exceptionally light in weight by comparison with stock of satisfactory weight. Of two pieces of stock of the same species and size, both free from visible defects and stored under like conditions, the heaviest piece normally has the highest strength.

b. Moisture content.—Moisture is contained in saturated wood as free water within the cell cavities and as hygroscopic moisture within the cell walls. The free or excess water has no effect as such on volume or strength; however, after it has been drawn off and water begins to come from the cell walls, the wood shrinks and at the same time increases rapidly in strength of load-bearing properties. Those that represent toughness or shock resistance sometimes actually decrease as the wood dries, because dried wood will not bend as far as green wood before failure, toughness being dependent upon both strength and pliability. In drying, the greatest shrinkage occurs in the direction of the annual growth rings (tangentially); about one-half to two-thirds as much across these rings (radially), and as a rule, very little along the grain (longitudinally). In drying, internal stresses are set up which tend to cause checks and other defects. The more the wood is dried, the greater is the tendency of these defects to develop.

Source: *Aircraft Woodwork*, Technical Manual No. 1-414, Washington, D.C.: War Department, 1942.

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TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Organic — Of, related to, or derived from living organisms

B. Mildew — Whitish growth produced on organic matter by fungi

C. Decay (rot) — Decomposition of cellulose (organic material) by fungi

D. Water penetration — Condition where water has entered a joint, fastener hole, or the fibers of the wood used in a wooden structure

E. Solid spar — Member (spar or beam) consisting of one piece of wood

F. Laminated wood — Assembly of two or more layers of wood which have been glued together with the grain of all layers approximately parallel

G. Plywood — Assembled product of wood and glue that is usually made of an odd number of thin plies with the grain of each layer at an angle of 90 degrees with the adjacent ply or plies

H. Adhesive — Substance used to bond two materials together by chemical means

I. Scarf joint — Type of joint used for the construction or repair of a wooden aircraft or component

(NOTE: The two parts to be joined are cut with a taper of one inch in ten.)

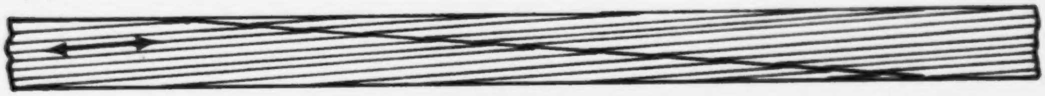
J. Splayed patch — Flush repair to a wood surface where the edges of the patch are tapered, but the slope is steeper than allowed in scarfing operations

K. Gusset — Small reinforcing member used to support the corners of a structure

L. Casein glue — Powdered glue made from milk

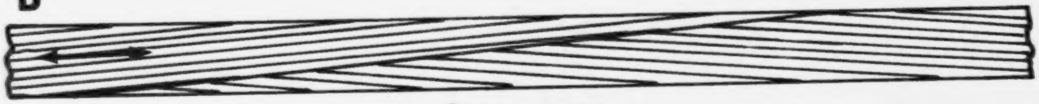
Consideration of Grain Direction When Making Scarf Joints

A



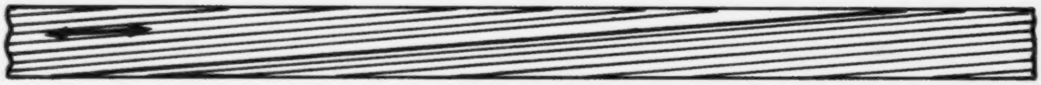
Incorrect

B



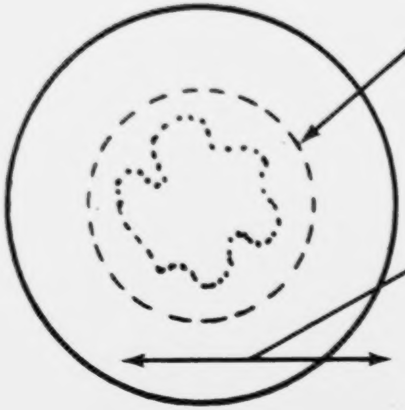
Incorrect

C



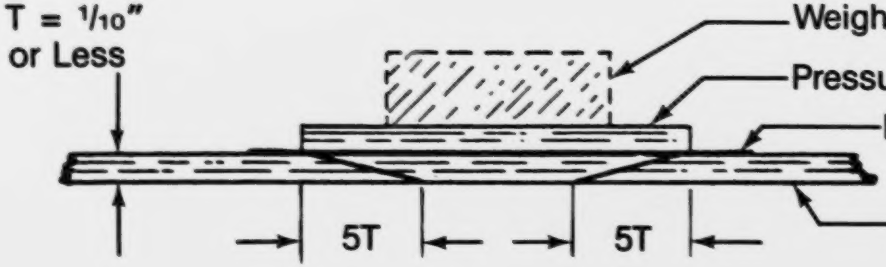
Correct

Splayed Patch



Trim to Circular Shape
(15T Maximum Diameter.
Minimum Distance to Frame = 15T.)

Face Grain of Patch
Parallel to Face Grain of Skin



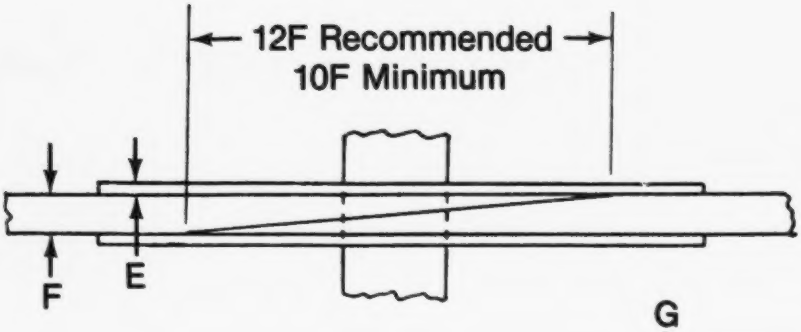
Weights or Clamp

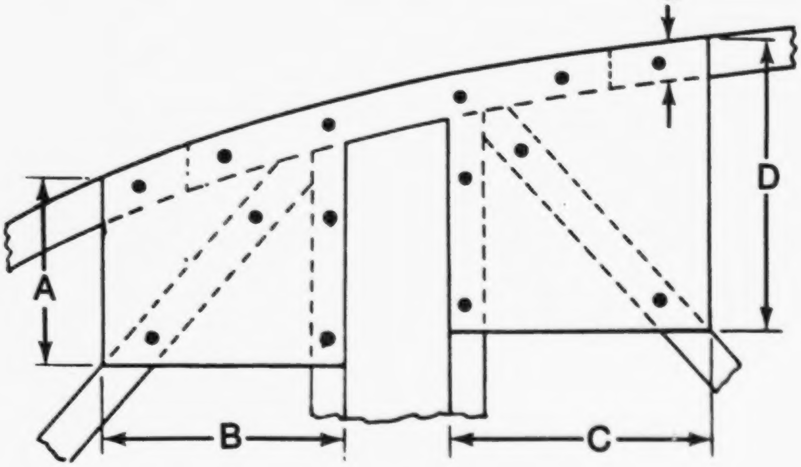
Pressure Plate 1/8" or 1/4" Plywood

Paper or Cellophane

Plywood Skin

Repair of Wooden Ribs


12F Recommended
10F Minimum
F
E

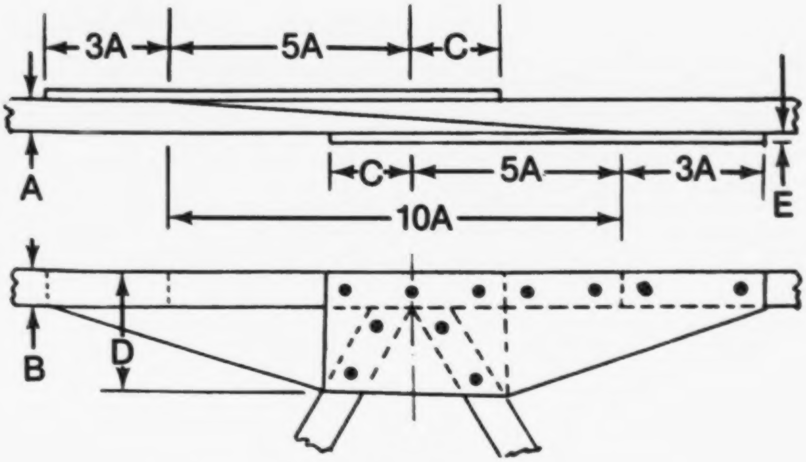


At a Spar

A, B, C, D, E, F, G = Original dimensions. Reinforcement plates shall be plywood glued and nailed. The direction of the face grain must be the same as original gusset.

Repair of Wooden Ribs

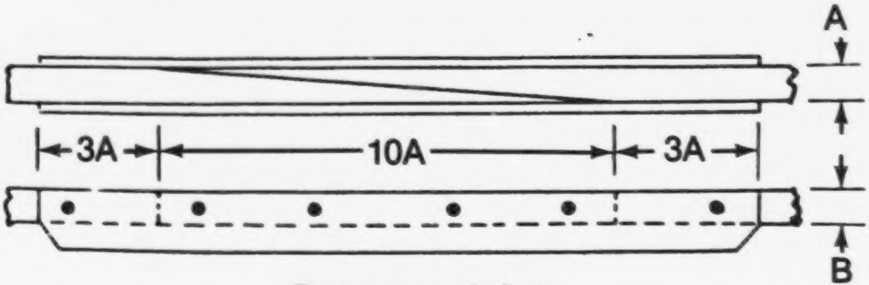
(Continued)



At a Joint to Truss Members

A, B, C, D, E = Original dimensions. Reinforcement plates shall be plywood glued and nailed. The direction of the face grain must be the same as original gusset.

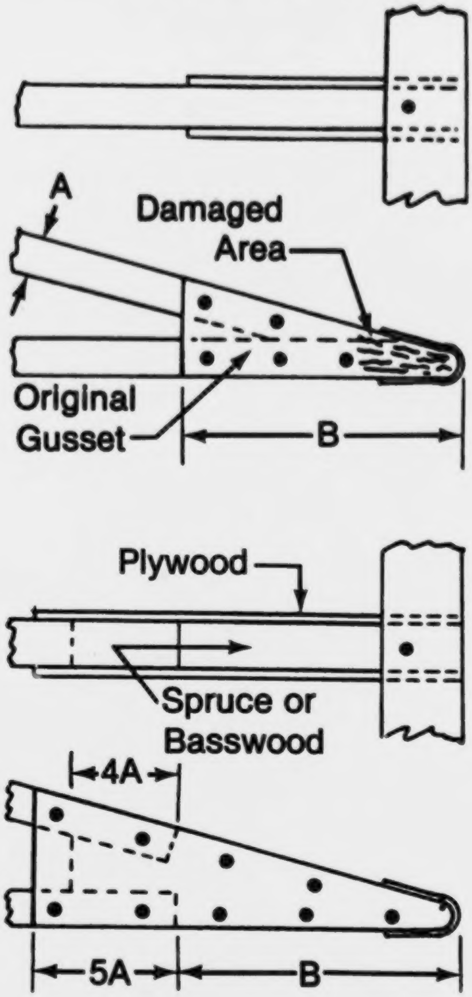
Repair of Wooden Ribs
(Continued)



Between Joints

A, B = Original dimensions. Reinforcement plates shall be plywood glued and nailed. The direction of the face grain must be the same as original gusset.

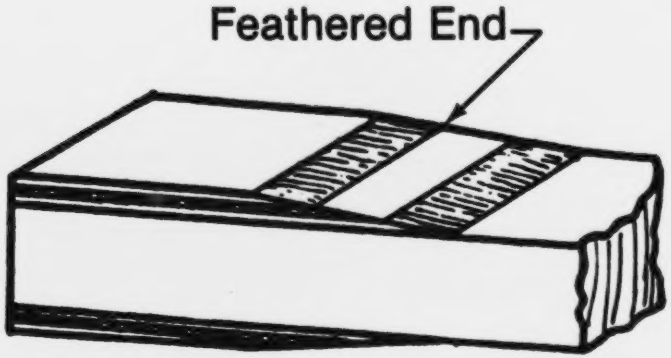
Repair of Wooden Ribs
(Continued)

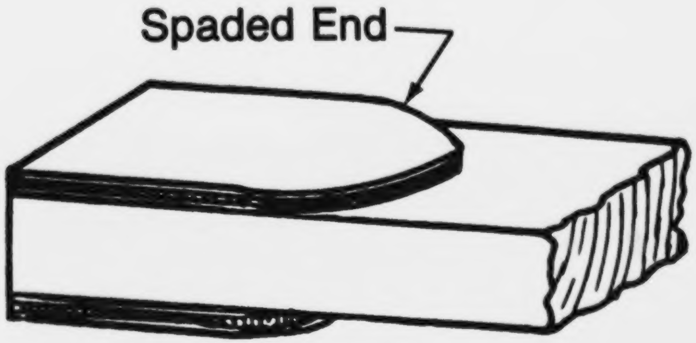

A
Damaged
Area
Original
Gusset
B
Plywood
Spruce or
Basswood
4A
5A
B

At Trailing Edge

A, B = Original dimensions. Reinforcement plates shall be plywood glued and nailed. The direction of the face grain must be the same as original gusset.

Tapering of Face Plates


Feathered End



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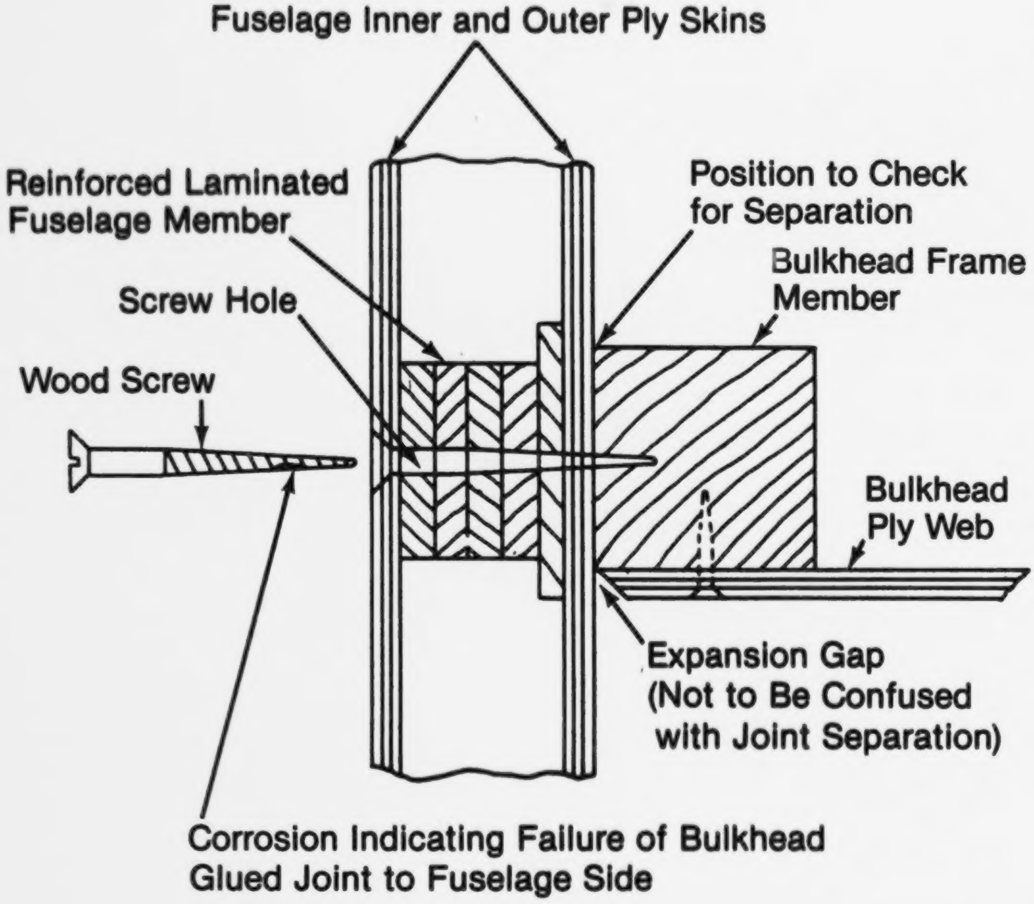
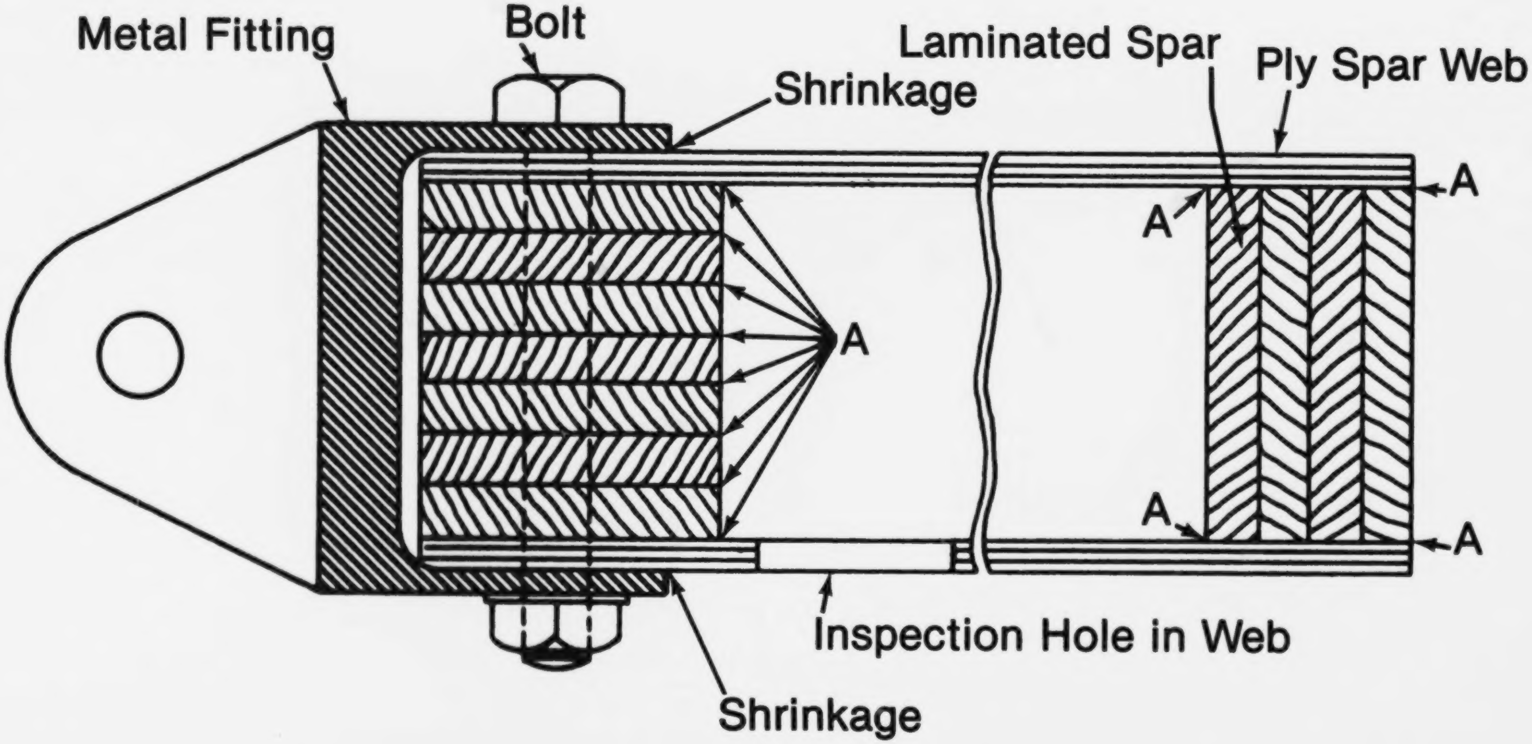
TM #7

Checking a Wooden Structure for Water Penetration


Fuselage Inner and Outer Ply Skins
Reinforced Laminated Fuselage Member
Position to Check for Separation
Bulkhead Frame Member
Screw Hole
Wood Screw
Bulkhead Ply Web
Expansion Gap (Not to Be Confused with Joint Separation)
Corrosion Indicating Failure of Bulkhead Glued Joint to Fuselage Side

Source: EA-AC 65-15A.

Laminated Joint


Metal Fitting
Bolt
Laminated Spar
Ply Spar Web
Shrinkage
A
A
A
A
A
Inspection Hole in Web
Shrinkage

At all points marked "A," check for glue condition and separation.

Source: EA-AC 65-15A.

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WORKBOOK SUPPLEMENT #1 — Interpret Characteristics of Wood

There are many species of wood, and the characteristics of these woods vary greatly. If aviation maintenance technicians are going to properly repair wooden structures, they must know these species and their characteristics in order to determine their applicability and workability. The aviation maintenance technician must also know how to recognize defects in wood and be able to determine acceptability to facilitate inspection and repair.

A. Using your reference material, answer the following questions.

1. What is the purpose of repairing wooden structural parts?

____

____

2. What is the reference wood used for aircraft structures?

____

3. Why is Douglas fir less suitable for aircraft structures than Sitka spruce?

____

____

____

4. What types of wood may be used as direct substitutes for spruce without increase in size?

____

____

____

5. What is the maximum permissible grain deviation (slope of grain) in wood used for aircraft construction?

____

6. Discuss the differences of solid wood, laminated wood, and plywood.

____

____

____

____

____

____

____

____

____

B. Identify the following wood defects as permitted or not permitted. Write a "P" in the blanks before those defects that are permitted and "NP" in the blanks before those that are not permitted.

______ 1. A spiral grain that diverges 2 inches away from the longitudinal axis for every 16 inches of longitudinal length

______ 2. Some of the wood is found to have buckled fibers which appear as streaks on the piece's surface at right angles to the grain

______ 3. A small cluster of pin knots that produce no appreciable grain direction change

______ 4. Some of the wood comes up in chunks when picked with the sharp point of a pocket knife

______ 5. A diagonal grain which has a slope deviation of 2 inches divergence away from the longitudinal axis for every 30 inches in longitudinal length

______ 6. A hard knot of 7/16 inch diameter is found

______ 7. A small group of pitch pockets, none closer than 15 inches, none larger than 1 1/2 inches long by 1/8 inch wide by 1/8 inch deep, and all are located along the center of the wood

______ 8. Mineral streaks with no decay present

______ 9. Curly grain not exceeding the 1:15 slope deviation

______10. Some of the wood is found to have small checks and shakes

______11. Some of the wood is found to have excessive amounts of summerwood, and there is little color contrast between the summerwood and springwood

______12. Spike knots are found in the center of a beam

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WORKBOOK SUPPLEMENT #2 — Outline Procedures for Performing a Scarf Joint and an Oval or Round Plug Patch Repair

An aviation maintenance technician must know the different repair processes and must know the order of procedures used to perform the repairs. This will ensure that a repair is done properly and that it is done with a minimum expenditure of time and money.

The exercises in this supplement will help you to develop the planning skills and knowledge necessary to accomplish two types of repairs.

A. Using AC 65-15A, pages 234-235, as reference material, identify and list in order the procedures necessary to produce a scarf joint used in splicing materials.

B. Arrange in order the processes for making an oval or round plug patch repair to a plywood skin. Write a "1" in the blank before the first step, a "2" before the second step, and so on.

______1. Lay the patch over the damaged spot, and mark a circle the same size as the patch

______2. Cut the doubler through one side so that it can be inserted through to the back of the skin; apply a coat of glue to the outer half of the doubler surface where it will bear against the inner surface of the skin

______3. Apply pressure to the patch by using a pressure plate and No. 4 wood screws placed at approximately 1-inch intervals

______4. Cut a patch of the correct dimension for the repair

______5. Install the doubler by slipping it through the cutout hole and centering it so that it is concentric with the hole; nail the doubler in place with nailing strips (waxed paper must be placed between the nailing strips and the skin), using a bucking bar or similar object for backing

______6. Cut a doubler of 1/4-inch plywood so that its outside radius is 5/8 inch greater than the hole to be patched and the inside radius is 5/8 inch less; for a large patch, these dimensions would be 7/8 inch each

______7. After the glue has set, remove the nails and screws; fill the nail and screw holes, sand, and finish to match the original surface

______8. Cut out the skin so that the patch fits snugly into the hole around the entire perimeter

______9. After the glue used in the installation of the doubler has set, apply glue to the surface of the doubler where the patch is to join and to the same area on the patch; insert the patch in the hole

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WORKBOOK SUPPLEMENT #3 — Discuss Inspection and Repairs of Wooden Structures

Damage or deterioration occurring in a wooden structure can only be determined by carefully inspecting all external and internal wood conditions, glued joints, and the many holes and bushings providing passages for items of hardware used in aircraft structures. Stress concentrates at fixtures used to connect various parts of the aircraft, and the holes and bushings which are a part of these fixtures can only be repaired by following strict guidelines. Spars and ribs are structural members which give the wing its shape and strength. These structural components must be repaired skillfully if the strength, rigidity, and aerodynamic shape are to be retained.

This workbook supplement is intended to reinforce your knowledge of the inspection process of wooden structures and of the accomplishment of repairs to spars, ribs, and bolt/bushing holes. Discuss inspection and repairs of wooden structures by answering the following questions.

A. What taper is used to make a splice in the cap strip of a wooden wing rib?

____

____

B. What size and type of wood is normally used for gussets on a wooden wing rib?

____

C. What is the maximum number of splices that is allowed in a wooden wing spar?

____

D. What is done to each end of a splice in a wing spar after the glue has cured?

____

____

E. What must be done in the case of elongated bolt holes in a spar or cracks in the vicinity of bolt holes?

____

____

F. What is the best angle at which to sharpen a twist drill for drilling holes in wooden spars?

____

G. How should a wood aircraft be prepared for an inspection?

____

____

H. What may be indicated by a split in the fabric covering the aircraft's plywood skin?

____

____

I. Where would you expect to find deterioration resulting from water being in contact with the wood?

____

____

J. What must be done occasionally in ply structures to facilitate inspection?

____

____

K. What are the three common factors which cause glue deterioration?

1. ______________________________
2. ______________________________
3. ______________________________

L. What must be done prior to checking a glue line?

____

____

M. What two tools should be used for inspecting a glue line?

1. ______________________________
2. ______________________________

WORKBOOK SUPPLEMENT #3

N. When using a feeler gage to inspect a glued joint, when should the joint be regarded as defective?

O. What is the indication of dry rot?

P. What should be done if water penetration is suspected?

Q. What is the general rule of thumb for replacing screws in wooden structures?

R. What can be done to confirm compression failure if this defect is suspected?

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ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #1

A.

1. To obtain a structure as strong as the original, with the same rigidity, and the same aerodynamic shape
2. Sitka spruce
3. Douglas fir is more difficult to work with using hand tools than spruce, and it has some tendency to split during fabrication
4. Douglas fir, noble fir (providing shear does not become critical), western hemlock, white cedar (Port Orford)
5. 1:15
6. Solid wood refers to a member consisting of one piece of wood. Laminated wood is an assembly of two or more layers of wood which have been glued together with the grain of all layers or laminations approximately parallel. Plywood is an assembled product of wood and glue that is usually made of an odd number of thin plies with the grain of each layer at an angle of 90 degrees with the adjacent ply or plies

B.

1. NP
2. NP
3. P
4. NP
5. P
6. NP
7. P
8. P
9. P
10. NP
11. NP
12. NP

Workbook Supplement #2

A. Evaluated to the satisfaction of the instructor

B.

1. 2
2. 5
3. 8
4. 1
5. 6
6. 4
7. 9
8. 3
9. 7

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #3

A. A taper of 10 to 12 times the width of the cap strip
B. $^{1}/_{16}$-inch mahogany plywood
C. No spar should have more than two splices
D. Glue reinforcement plates over both ends of the scarf
E. Splice in a new section of spar, or replace the spar entirely
F. 60-degree angle
G. It should be opened up completely and left in a dry, well-ventilated area for as long as possible prior to performing the inspection
H. Damage to the wood underneath the fabric
I. In the lower parts of the structure
J. Access holes must be cut
K. 1. Chemical reactions of the glue
    2. Mechanical forces
    3. Fungus growths
L. Remove all protective coatings of paint
M. 1. Magnifying glass
    2. Thin feeler gage
N. If the feeler gage penetrates the joint
O. Small patches of crumbling wood
P. Remove a few screws from the suspected area, and check them for corrosion
Q. Replace screws with screws of the same length but one gage larger
R. A flashlight should be shone along the member, with the beam of light running parallel to the grain

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PROJECT GUIDE #1 — Inspect a Wooden Structure

PURPOSE: To help you develop skill in performing inspections on wooden aircraft structures.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. AC 43.13-1A&2A

EQUIPMENT AND TOOLS:

A. Wooden wing or wooden fuselage (with stations labeled) with plywood skin partially removed

B. Flashlight

C. 10X magnifying glass

D. Small pocket knife with sharp point

E. Thin feeler gage appropriate for glued joints to be inspected

SUPPLIES AND MATERIALS:

A. Lint-free rags

B. Pencil

PROCEDURE:

A. Use rags to clean any dirt or residue from wood surfaces

(NOTE: This procedure will be done throughout the inspection.)

B. Use flashlight, magnifying glass, and pocket knife to inspect structure for decay, dry rot, or any condition which decreases the strength of wood (Figure 1)

FIGURE 1

C. Record wood condition inspection findings on discrepancy sheet at end of project guide

D. Use pocket knife to carefully remove any protective coatings from glue lines to be inspected (Figure 2)

FIGURE 2

E. Inspect all glued joints in structure; use feeler gage to check glue line (Figure 3)

FIGURE 3

F. Record glued joint inspection findings on discrepancy sheet

G. Inform instructor of any defects which necessitate repair

H. Clean work area, and return tools and equipment to proper storage area

PROJECT GUIDE #1

Discrepancy Sheet

Wood Condition Inspection

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

Glued Joint Inspection

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

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A201-B

THEORY TEST

1. Match terms related to inspection and repair of wooden structures to their correct definitions. Write the correct numbers in the blanks.

_____a. Small reinforcing member used to support the corners of a structure

_____b. Decomposition of cellulose (organic material) by fungi

_____c. Flush repair to a wood surface where the edges of the patch are tapered, but the slope is steeper than allowed in scarfing operations

_____d. Powdered glue made from milk

_____e. Of, related to, or derived from living organisms

_____f. Assembly of two or more layers of wood which have been glued together with the grain of all layers approximately parallel

_____g. Type of joint used for the construction or repair of a wooden aircraft or component

_____h. Whitish growth produced on organic matter by fungi

_____i. Member (spar or beam) consisting of one piece of wood

_____j. Assembled product of wood and glue that is usually made of an odd number of thin plies with the grain of each layer at an angle of 90 degrees with the adjacent ply or plies

_____k. Condition where water has entered a joint, fastener hole, or the fibers of the wood used in a wooden structure

_____l. Substance used to bond two materials together by chemical means

1. Casein glue
2. Laminated wood
3. Gusset
4. Splayed patch
5. Scarf joint
6. Decay (rot)
7. Organic
8. Plywood
9. Adhesive
10. Mildew
11. Water penetration
12. Solid spar

THEORY TEST

2. The following is a list of statements pertaining to materials used to construct and repair wooden aircraft structures. Select true statements related to forms of wood commonly used in aircraft. Circle the letters before the correct answers.

   a. The one and only criterion for any wooden aircraft repair is that it should be as strong as the original structure

   b. Sitka spruce is the reference wood for aircraft structures

   c. No other woods except Sitka spruce are FAA approved for use in aircraft structures

   d. Laminated wood used in highly stressed structures can be identified by its parallel grain construction

   e. Western hemlock is less uniform in texture than spruce, may be used as a direct substitute, and has satisfactory gluing characteristics

   f. The maximum permissible grain deviation is 1:15 for all woods used in aircraft

   g. The strength properties of northern white pine slightly exceed those of spruce

3. Below is a list of conditions found to exist in wood received at your shop. Distinguish between defects which are permitted and defects which are not permitted in woods used for aircraft repair. Write a "P" for defects permitted or an "NP" for defects not permitted in the blanks.

   ______a. A diagonal grain which diverges, after all four faces have been checked, at more than a 1:15 slope

   ______b. A mineral streak which fails to reveal any decay

   ______c. Two hard knots which are 30 inches apart

   ______d. A hard knot which is $^{7}/_{16}$ inch in diameter

   ______e. Spike knots running perpendicular to the annual rings

   ______f. Compression wood

   ______g. Wood with checks, shakes, and splits

   ______h. Small pin knot clusters producing a small effect on grain direction

THEORY TEST

4. Match terms related to synthetic resin glues and their applications to their correct definitions. Write the correct numbers in the blanks.

______a. Material used to promote the setting of glue. It may be supplied separately in either liquid or powder form, or it may have been incorporated with the resin by the manufacturer. It is an essential part of the adhesive, the properties of which depend upon using the resin and hardener as directed

______b. Spread of adhesive equally divided between the two surfaces to be joined

______c. Composition substantially consisting of a synthetic resin, either the phenolic or amino type, but including any hardening agent or modifier which may have been added by the manufacturer or which must be added before use according to manufacturer's instructions

______d. Period of time between the application of the adhesive and the assembly of the joint components

______e. Time elapsing between the assembly of the joints and the application of pressure

______f. Resultant layer of adhesive joining any two adjacent wood layers in the assembly

______g. Amount of adhesive applied to join two surfaces

1. Synthetic resin adhesive
2. Closed assembly time
3. Hardener
4. Spread of adhesive
5. Open assembly time
6. Glue line
7. Double spread

THEORY TEST

______h. Nongap-filling adhesive suitable for use only in those joints where the surfaces to be joined can be brought into close contact by means of adequate pressure, and where glue lines exceeding 0.005 inches can be avoided with certainty

______i. Adhesive suitable for use in those joints where the surfaces to be joined may or may not be in close or continuous contact, owing either to the impossibility of applying adequate pressure or to slight inaccuracies of machining

______j. Derived from the reaction of a phenol with an aldehyde; this substance (amino plastic) is from the reaction of urea, thiourea, melamine, or allied compounds with formaldehyde

______k. Adhesive which sets and hardens satisfactorily at ordinary room temperature, 50°F to 86°F (10°C to 32°C), within a reasonable period

______l. Spread of adhesive to one surface only

8. Synthetic resin
9. Gap-filling adhesive
10. Close contact adhesive
11. Single spread
12. Cold setting adhesive

5. Select statements related to gluing processes. Circle the numbers before the correct answers.

   a. The strength of a glue joint must be equal to

      1) 75 percent of the wood strength

      2) the strength of the wood

      3) twice the strength of the wood in tension

      4) 50 percent of the wood strength

   b. The strength of a well-designed and properly prepared wood splice joint is provided by the

      1) bearing surface of the wood fibers

      2) doubler

      3) glue

      4) reinforcement plates

THEORY TEST

c. If resin glue is placed over a casein glue, the resin glue joint will not cure properly because of the casein glue's

1) alkalinity

2) acidity

3) texture

4) aromatic substances

d. Open assembly time is the

1) length of time allowed between assembling the joint and applying pressure

2) amount of time after finishing the wood surface and applying glue

3) method of applying and relieving pressure on the glue joint for specific periods of time

4) length of time allowed between the application of glue and the assembly of the joint

e. When gluing hardwoods, the pressure used to cure the glue is

1) 125 to 150 psi

2) 150 to 300 psi

3) 150 to 200 psi

4) 100 to 400 psi

f. When testing a glued joint sample fabricated from pieces derived from the actual component, the fractured glue faces should show what percentage of the wood fibers evenly distributed over the fractured glue faces?

1) 100 percent

2) 75 percent

3) 60 percent

4) 85 percent

THEORY TEST

6. Discuss the fabrication of a spliced joint used to repair a structural member by answering the following questions.

   a. When using a scarf joint to splice structural members, what should be the slope of the bevel in solid wood?

      ____

   b. How much time is recommended between final surfacing and gluing?

      ____

   c. Why should a scarfed joint for a splice to a spruce wing spar not be sanded?

      ____

      ____

      ____

7. Select statements related to plywood skin repairs. Circle the numbers before the correct answers.

   a. When patching a plywood skin, abrupt changes in cross-sectional areas which will develop dangerous stress concentration should be avoided by using

      1) circular or elliptical patches

      2) rectangular patches

      3) square patches

      4) doublers with any desired shaped patches

   b. Which of the following types of patches is preferred for repairing stressed plywood skin?

      1) Surface patch

      2) Splayed patch

      3) Plug patch

      4) Scarf patch

c. Surface patches should not be used on skins over

1) 1/4 inch thick

2) 1/8 inch thick

3) 1/2 inch thick

4) 1/16 inch thick

d. A patch should be large enough to extend at least

1) 10 times the skin thickness beyond all edges of the opening

2) 5 times the skin thickness beyond all edges of the opening

3) 12 times the skin thickness beyond all edges of the opening

4) 15 times the skin thickness beyond all edges of the opening

e. The maximum thickness of plywood aircraft skin that can be patched with a splayed patch is

1) 1/10 inch

2) 1/4 inch

3) 1/2 inch

4) 1/5 inch

f. A doped-on fabric patch can be used where a hole is not nearer than 1 inch to any frame member, or in the leading edge of a wing, or in the frontal area of a fuselage providing the hole is no larger than

1) 2 inches in diameter

2) 1 1/2 inches in diameter

3) 1/2 inch in diameter

4) 1 inch in diameter

8. The repair of damage in a plywood skin using an oval or round plug patch requires a specific sequence in operations. Arrange in proper order the steps for making an oval or round patch for a plywood skin. Write a "1" in the blank before the first step, a "2" before the second step, and so on.

______a. Lay the patch over the damaged spot, and mark a circle the same size as the patch

______b. Install the doubler by slipping it through the cutout hole and centering it so that it is concentric with the hole; nail the doubler in place with nailing strips (waxed paper must be placed between the nailing strips and the skin), using a bucking bar or similar object for backing

______c. Cut out the skin so that the patch fits snugly into the hole around the entire perimeter

______d. Cut a patch of the correct dimension for the repair

______e. After the glue has set, remove the nails and screws; fill the nail and screw holes, sand, and finish to match the original surface

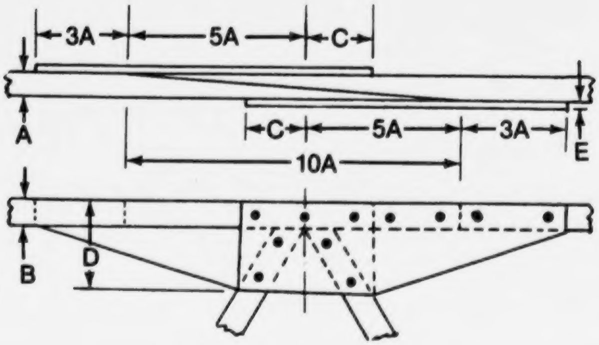
______f. Cut a doubler of ¼-inch plywood so that its outside radius is ⅝ inch greater than the hole to be patched and the inside radius is ⅝ inch less; for a larger patch, these dimensions would be ⅞ inch each

______g. Apply pressure to the patch by using a pressure plate and No. 4 wood screws placed at approximately 1-inch intervals

______h. Cut the doubler through one side so that it can be inserted through to the back of the skin; apply a coat of glue to the outer half of the doubler surface where it will bear against the inner surface of the skin

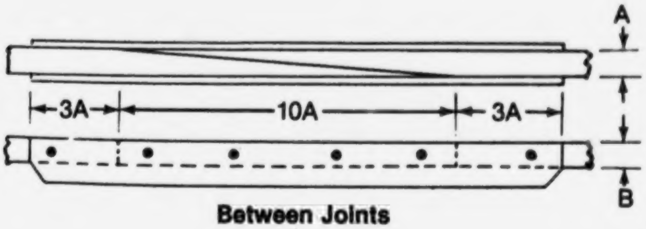
______i. After the glue used in the installation of the doubler has set, apply glue to the surface of the doubler where the patch is to join and to the same area on the patch; insert the patch in the hole

9. a. Use the detailed drawing below to answer the following questions pertaining to the dimensions and procedures for a wooden rib repair.



At a Joint to Truss Members

A, B, D, D, E =
Original dimensions.
Reinforcement plates shall be
plywood glued and nailed.
The direction of the face
grain must be the same
as original gusset.



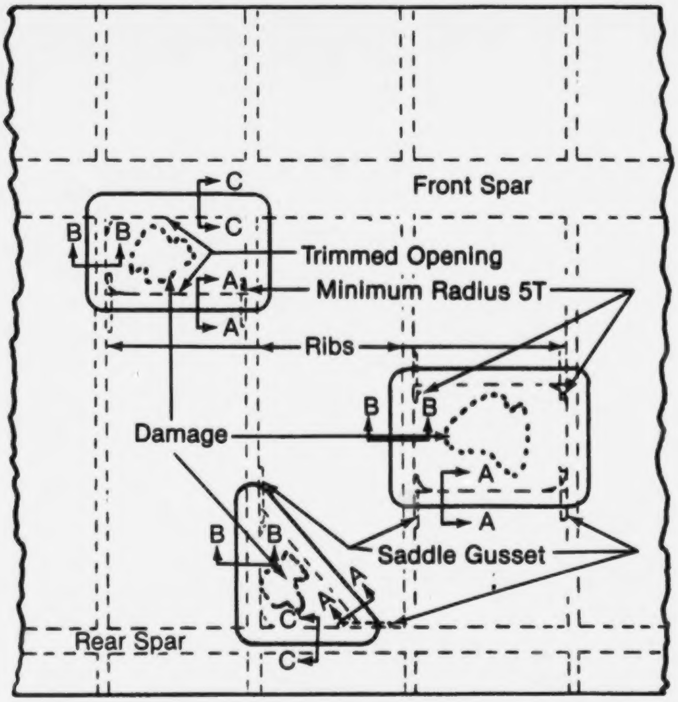
Between Joints

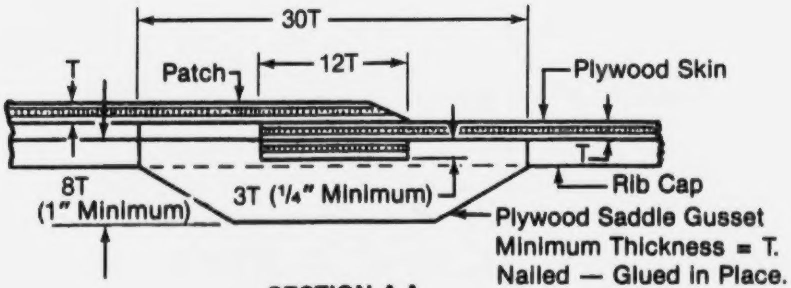
1) If the dimension "A" is equal to 3/8 inch (this is the width of the rib cap member), how long is the scarf cut where the rib is being spliced at a joint to truss member?

2) If the dimension "A" is equal to 1/4 inch (this is the width of the rib cap member), how far does the reinforcement plate extend beyond the scarf cut where the rib is being spliced between joints?

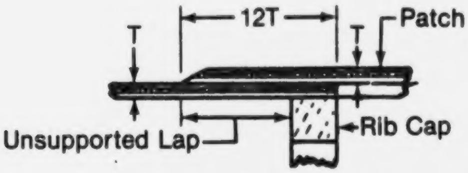
3) How are the reinforcement plates attached to the structure?

b. Use the detailed drawing below to answer the following questions pertaining to the dimensions and procedures for surface patch repairs.

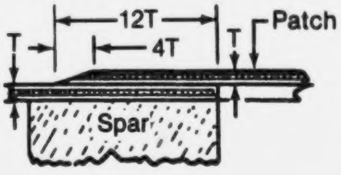

C
C
Front Spar
B
B
Trimmed Opening
A
Minimum Radius 5T
A
Ribs
B
B
Damage
A
A
B
B
Saddle Gusset
A
A
C
Rear Spar
C


30T
T
Patch
12T
Plywood Skin
T
Rib Cap
8T
(1" Minimum)
3T (¼" Minimum)
Plywood Saddle Gusset
Minimum Thickness = T.
Nailed — Glued in Place.

SECTION A-A


T
12T
T
Patch
Unsupported Lap
Rib Cap

SECTION B-B


T
12T
4T
T
Patch
Spar

SECTION C-C

THEORY TEST

1) If the dimension "T" is equal to 5/16 inch, what is the minimum radius for the trimmed opening of a rectangular surface patch?

2) What is the overall length of the plywood saddle gusset used in a surface patch repair with the dimension "T" being equal to 1/4 inch?

10. Select statements related to spar, rib, and bolt/bushing hole repairs in wooden structures. Circle the numbers before the correct answers.

    a. In cases of elongated bolt holes in a wooden spar or cracks in the vicinity of bolt holes,

        1) it is permissible to plug the hole with hardwood and redrill

        2) a plug should be inserted in the hole and a reinforcement plate added

        3) the spar may be reinforced by using birch reinforcing plates

        4) a new section of spar should be spliced in or the spar replaced entirely

    b. Laminated wooden spars may be substituted for solid rectangular wooden spars

        1) only in certain instances where the primary load is shared by one or more other original structural members

        2) only if the strength deficiency is allowed for by an increase in dimension

        3) if the same quality wood is used in both

        4) only upon specific approval by the manufacturer or the FAA

    c. Small aircraft nails are used in making repairs to a wooden rib cap to

        1) provide the needed structural strength

        2) provide the pressure needed to make a strong glue joint

        3) provide a means for attaching the drag wires

        4) provide a means for attaching reinforcement plates

d. When repairing a solid wood spar, the reinforcing plates should be

1) one-fourth as thick as the spar and should extend beyond each end of the crack for at least three times the thickness of the spar

2) one-eighth as thick as the spar and should extend beyond each end of the crack for at least three times the thickness of the spar

3) one-sixth as thick as the spar and should extend beyond each end of the crack for at least five times the thickness of the spar

4) one-half as thick as the spar and should extend beyond each end of the crack for at least two times the thickness of the spar

11. Aviation maintenance technicians routinely inspect wooden aircraft structures. There are general and specific procedures used to accomplish these inspections. Discuss factors related to wood condition inspection, glued joint inspection, and procedures used when inspecting wooden structures by answering the following questions.

a. Why is it recommended that an aircraft be completely opened and kept in a well-ventilated hangar for as long as possible prior to making an inspection?

____

____

b. The wings, fuselage, and empennage should be checked visually on an external inspection for which conditions?

____

____

c. What are the three most common factors and their causes for glue joint deterioration?

1) ______________________________

____

2) ______________________________

____

3) ______________________________

____

THEORY TEST

d. What should be done prior to checking a glue line?

____

____

e. How can you determine whether discolored wood is rotten or sound?

____

____

____

12. Inspect a wooden structure.

(NOTE: Test question 12 is a project guide. It is an important part of this test. If it has not been completed, check with your instructor.)

AIRFRAME
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INSPECT WOODEN STRUCTURES
A201-B

ANSWERS TO THEORY TEST

1. a. 3
   b. 6
   c. 4
   d. 1
   e. 7
   f. 2
   g. 5
   h. 10
   i. 12
   j. 8
   k. 11
   l. 9

2. b, d, e, f

3. a. NP
   b. P
   c. P
   d. NP
   e. NP
   f. NP
   g. NP
   h. P

4. a. 3
   b. 7
   c. 1
   d. 5
   e. 2
   f. 6
   g. 4
   h. 10
   i. 9
   j. 8
   k. 12
   l. 11

5. a. 2
   b. 3
   c. 1
   d. 4
   e. 3
   f. 2

6. a. Ten to one
   b. Eight hours
   c. Sanding dust will fill the softwood's pores and cause a weak glue joint

7. a. 1
   b. 4
   c. 2
   d. 3
   e. 1
   f. 4

8. a. 2
   b. 6
   c. 3
   d. 1
   e. 9
   f. 4
   g. 8
   h. 5
   i. 7

ANSWERS TO THEORY TEST

9. a. 1) 3¾ inches long
   2) ¾ inch
   3) The reinforcement plates shall be plywood glued and nailed

   b. 1) 1$^{9}/_{16}$ inches
   2) 7½ inches

10. a. 4   c. 2
    b. 3   d. 1

11. a. Doing this will ensure that the aircraft is completely dried out, and this will facilitate the glued joint inspection

    b. Undulation, warping, and other departures from the original shape

    c. 1) Chemical reactions caused by aging, moisture, and extreme temperatures
    2) Mechanical forces caused by shrinkage
    3) Fungus growths caused by moisture penetration

    d. Carefully remove all protective coatings of paint

    e. Pick the wood with sharp point of a pocket knife. If the wood pulls up in chunks, it is rotten; if it splinters, it is probably good

12. Performance skills evaluated to the satisfaction of the instructor

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MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

AIRFRAME

A201 AIRCRAFT STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

INSPECT AND REPAIR BONDED STRUCTURES

A201-C

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
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2. Technical Information Supplement #2 — Safety
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2. Workbook Supplement #2 — Describe the Types and Characteristics of Bonded Structures
3. Workbook Supplement #3 — Analyze Statements Related to Fiberglass and Composite Bonded Structure Repair Procedures
4. Workbook Supplement #4 — Classify Bonded Honeycomb Structural Repairs
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6. Workbook Supplement #6 — Discuss Repair Techniques Used on Bonded Structures

MODULE CONTENTS

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    2. Project Guide #2 — Remove Damage from Metal Bonded Honeycomb with a Router
    3. Project Guide #3 — Perform Potted Compound Repairs to Metal Bonded Honeycomb
    4. Project Guide #4 — Perform Core Replacement and Glass Overlay on Metal Bonded Honeycomb

I. Theory Test

J. Answers to Theory Test

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
A201-C

INTRODUCTION

The space age has introduced to our technology new and revolutionary materials and methods of aircraft construction. Probably the most important new structural development has been the introduction of composite structural materials. As an aviation maintenance technician, you will be required to inspect and repair bonded structures. This module will help you develop competency in the inspection and repair processes of bonded structures.

MODULE OBJECTIVE

After completion of this module, you will be able to repair surface scratches in composite laminate, remove damage from metal bonded honeycomb, perform potted compound repairs, and perform core replacement and glass overlay on metal bonded honeycomb. Your competency will be evaluated by completing workbook assignments, project guides, and by scoring a minimum of 85 percent on the module theory test.

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A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
A201-C

SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

1. Match terms related to bonded structures to their correct definitions. (1)	Technical Supplement #1
2. State general safety rules to observe when repairing or fabricating bonded structures. (1)	Technical Supplement #2
3. Match materials related to fiberglass and composite bonded structure repair to their correct usages and characteristics. (1)	Technical Supplement #3 EA-ITP-AB 51-55 Workbook Supplement #1 EA-ITP-AW 1:II:11-12 EA-ITP-ASG 6-7:28-43
4. Match materials related to metal bonded honeycomb structure repair to their correct usages. (1)	Technical Supplement #4 EA-ITP-AB 51-55 AC 65-15A 205-206 Workbook Supplement #1 EA-ITP-AW 1:II:11-12 EA-ITP-ASG 6-7:28-43
5. Select true statements related to types and characteristics of bonded structures. (1)	Technical Supplement #5 EA-ITP-AB 55-56 AC 65-15A 200-201 Workbook Supplement #2 EA-ITP-ASG 7:44-47
6. Discuss work procedures related to repairing fiberglass and composite bonded structures. (1)	EA-ITP-AB 56-61,64-67 AC 65-15A 221-224 AC 43.13-1A&2A 74-76 Workbook Supplement #3 EA-ITP-AW 1:II:12 EA-ITP-ASG 7-8:49-54
7. Describe how the tap test and visual inspection are accomplished on fiberglass and composite bonded structures. (1)	Technical Supplement #6 EA-ITP-AB 56-57 Workbook Supplement #3 EA-ITP-ASG 7:48
8. Match the classes of repairs to fiberglass bonded honeycomb to their correct types of damage. (1)	Technical Supplement #7 AC 65-15A 224 Workbook Supplement #4

SPECIFIC OBJECTIVES

9. Match types of inspection techniques to the specific types of metal bonded honeycomb damage. (1)	Technical Supplement #8 AC 65-15A 201 Workbook Supplement #5
10. Match the classes of metal bonded honeycomb damage to their correct types of damage. (1)	Technical Supplement #8 Workbook Supplement #4
11. Select from a list repair techniques that will ensure defect-free repairs. (1)	Technical Supplement #9 EA-ITP-AB 57 Workbook Supplement #6 EA-ITP-AW 1:II:12
12. Match tools and equipment used in metal bonded honeycomb structure repair to their correct uses. (1)	Technical Supplement #10 EA-ITP-AB 57-58,64-66 Workbook Supplement #7 EA-ITP-AW 1:II:12
13. Select statements pertaining to repair procedures when given data related to metal bonded honeycomb repairs. (1)	EA-ITP-AB 61-67 AC 65-15A 206-213 AC 43.13-1A&2A 76-79 Workbook Supplement #7 EA-ITP-AW 1:II:12-13
14. Discuss characteristics of boron and graphite materials. (1)	Technical Supplement #11 Workbook Supplement #8
15. Repair surface scratches in fiberglass laminate. (2)	Project Guide #1
16. Remove damage from metal bonded honeycomb with a router. (2)	Project Guide #2
17. Perform potted compound repairs to metal bonded honeycomb. (2)	Project Guide #3
18. Perform core replacement and glass overlay on metal bonded honeycomb. (3)	Project Guide #4

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
A201-C

INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

(NOTE: Do not use information presented in this module for work of any kind on an airworthy aircraft. The procedures for bonding, applying, and repairing composite and metal bonded structures are emerging and changing at a phenomenal rate. These materials are intended for training purposes only. Use the manufacturer's structural repair manual which is current for the specific aircraft you are inspecting, maintaining, or repairing.)

NOTICE AND DISCLAIMER: This workbook is designed to be used as a study guide and is not intended to be used as an official service publication. It is not kept current, and therefore, cannot and should not be used as a substitute for current published service manuals, service bulletins and airworthiness directives. Cessna disclaims any liability for the technical data contained herein.

I. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

Estimated Teaching Time		Theory	Lab
Objective 1	Using Technical Information Supplement #1, discuss the terms and definitions related to bonded structures. Locate as many examples as possible which relate to the terms to use during your discussion.		
Objective 2	Using Technical Information Supplement #2, explain all safety rules, procedures, and precautions applicable to the bonded structure repair area. Give students Instructional Supplement #1. Have students complete a safety inspection of the shop area where they will be working, and then discuss strengths and weaknesses found in the safety inspection of the shop.		
Objectives 3-4	Using Technical Information Supplements #3 and #4, discuss the materials used in composite bonded and metal bonded honeycomb construction and repair. Have examples of all materials for the class to view. Use Transparency Master #1. Give students Instructional Supplement #2. Have students complete Workbook Supplement #1.		

Estimated Teaching Time		Theory	Lab
Objective 5	Use Technical Information Supplement #5 to discuss the various types of bonded structures found in aircraft. Be sure to explain the methods of construction and characteristics of the different types of structures. Explain the applications of the different types. Have cross-sectioned examples for the students to view. Use Transparency Masters #2-#9. Have students complete Workbook Supplement #2.		
Objective 6	Discuss the repairs which are approved for composite bonded structures. Use Transparency Masters #10-#12. Give students Instructional Supplement #3. Have cross-sectioned examples of a scarf repair and a step-joint repair for the students to examine. A good demonstration of a safety hazard which exists in this area could be showing the result of mixing accelerator directly with the catalyst. Perform this demonstration in a well-ventilated area, and have a fire extinguisher on hand. Place a few drops of accelerator on a shop rag, and add to this a few drops of catalyst. Place this rag on a surface that will not be harmed by high temperatures, smoke, or fire. This should effectively illustrate the result of mixing chemicals improperly.		

WARNING

Be sure to check with chemical manufacturer's instructions to ensure that only extreme heat will develop from this demonstration. Mixing some chemicals improperly could result in an explosion.

Estimated Teaching Time		Theory	Lab
Objective 7	Demonstrate and explain the tap test and visual inspection procedures for use on composite bonded structures. Allow the students to visually examine and to listen to the difference between a bonded and a delaminated structure. Use Transparency Master #13 and Technical Information Supplement #6. Have students complete Workbook Supplement #3, EA-ITP-AW 1:II:11-12, questions 1-15 and 18-19, and EA-ITP-ASG 6-8:28-54.		
Objective 8	Explain the classes of repairs and the types of damage to which they correspond relative to fiberglass bonded honeycomb. Use Technical Information Supplement #7.		
Objective 9	Explain the different inspection techniques used to detect the various types of damage which can occur to metal bonded honeycomb. Demonstrate the metallic ring test, and allow the students to see an example of a facing which has separated (oilcanned) away from the core. Use Technical Information Supplement #8. Have the students complete Workbook Supplement #5.		
Objective 10	Discuss the classification of repairs relative to metal bonded honeycomb damage. Use Technical Information Supplement #8. Have students complete Workbook Supplement #4. (NOTE: Part A of Workbook Supplement #4 relates to Specific Objective 8.)		
Objective 11	Discuss all the repair methods that will ensure defect-free repairs. Explain the results of not employing these methods. Use Technical Information Supplement #9. Have students complete Workbook Supplement #6.		

Estimated Teaching Time		Theory	Lab
Objectives 12-13	Show the tools and equipment used in metal bonded structure repair, and discuss their uses. Explain the most common types of repairs made to metal bonded honeycomb and all procedures used to make the repairs. Use Technical Information Supplement #10, Instructional Supplement #4, and Transparency Master #14. Have students complete Workbook Supplement #7 and EA-ITP-AW 1:II:12-13, questions 16-17 and 20-26.		
Objective 14	Discuss the new composite materials of boron and graphite. Use Technical Information Supplement #11. Have students complete Workbook Supplement #8.		
Objectives 15-18	Discuss Project Guides #1-#4 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures.		
	Prepare small pieces of fiberglass laminate structure, each piece approximately 8" × 8". Also prepare 12" × 12" pieces of metal bonded honeycomb. A carbide-type band-saw blade is required for cutting most types of metal bonded honeycomb.		
	The following three types of damage to metal bonded honeycomb will be simulated on honeycomb material prior to students completing Project Guide #2: location #1—damage to one skin and partial damage to core; location #2—damage to both skins and core; and location #3—damage to one skin and core to bond line. Location #1 and location #2 will be simulating damage of less than 1 inch in diameter, while location #3 will be simulating damage in excess of 1 inch in diameter. Be sure that there is adequate space between locations #1, #2, and #3 so that there will be sufficient space between the hole and the edge of the material or any other damage remaining after routing at location #3. This space will allow room for the proper tapes to be applied and will allow room for the overlay.		

Estimated Teaching Time	Theory	Lab
(NOTE: The router shown in the photographs in Project Guide #2 is a Dotco Model #1012582C 01. The router shown in Instructional Supplement #4 is an Acornad-1. Students should be made aware that various models may appear to be different from those shown; however, any router that operates within the required specifications can be used.) **WARNING** **Be sure to read all safety data sheets and directions pertaining to chemical hazards and mixing instructions. When in doubt, consult the manufacturer.** Have students complete the projects. Review the projects in class after all students have completed.		

AIRFRAME
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INSPECT AND REPAIR BONDED STRUCTURES
A201-C

INSTRUCTIONAL SUPPLEMENT #1

MATERIAL SAFETY DATA SHEET **CPN 5996371**

FENWAL INC.
400 MAIN ST.
ASHLAND, MA 01721
(617) 881-2000

SECTION I

TRADE NAME: 80055-045 Part B
CHEMICAL FAMILY: Epoxy Curing Agents
FORMULA: Propriety

SECTION II — HAZARDOUS INGREDIENTS, percent & TLV

This compound contains no materials identified as hazardous by either the Massachusetts Right to Know Law or by the OSHA Safety and Health Standards 29CFR1910 Subpart Z "Toxic and Hazardous Substances".

SECTION III — PHYSICAL DATA

BOILING POINT:	NA	SPECIFIC GRAVITY:	1.01
VAPOR PRESSURE (mm Hg):	NA	PERCENT VOLATILE:	NA
VAPOR DENSITY (air = 1):	NA	EVAPORATION RATE:	NA
SOLUBILITY IN WATER:	NA		
APPEARANCE & ODOR:	Clear Liquid		

SECTION IV — FIRE & EXPLOSION HAZARD DATA

FLASH POINT: 180°F
EXTINGUISHING MEDIA: CO_2, dry chemical, foam
SPECIAL FIRE FIGHTING PROCEDURES: Use self-contained breathing apparatus.
FLAMMABLE LIMITS — Lel: NA; Uel NA
UNUSUAL FIRE & EXPLOSION HAZARDS: None

SECTION V — HEALTH HAZARD DATA

THRESHHOLD LIMIT VALUE:	Not established for mixture. See Section II for hazardous constituents.
EFFECTS OF OVEREXPOSURE:	May cause injury to skin following prolonged or repeated contact and may cause skin sensitization or other allergic responses. SPI Class 3

INSTRUCTIONAL SUPPLEMENT #1

EMERGENCY AND FIRST AID PROCEDURES: Avoid inhalation of vapor. Use good ventilation particularly if heated or sprayed. Prevent contact with skin. If contact occurs, wash immediately with soap and water. If irritation occurs, remove individual from further contact with material.

SECTION VI — REACTIVITY DATA

STABILITY: Stable

CONDITIONS TO AVOID:	Storage at elevated temperatures over long periods of time
INCOMPATIBILITY:	Epoxy resins under uncontrolled conditions, strong acids.
HAZARDOUS DECOMPOSITION PRODUCTS:	Toxic fumes at decomposition temperatures.
HAZARDOUS POLYMERIZATION:	Will not occur
CONDITIONS TO AVOID:	

SECTION VII — SPILL OR LEAK PROCEDURES

Scoop up excess and remove. Residual can be removed with nonflammable solvent. Incinerate in accordance with local pollution regulations and ordinances.

SECTION VIII — SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:	NIOSH-approved organic vapor respirator
VENTILATION:	Local & mechanical exhaust
OTHER PROTECTIVE EQUIPMENT:	Impervious gloves, splash-proof goggles, safety shower, and eye-wash facilities.

The information supplied here is based on data we consider to be accurate. No warranty, expressed or implied is made. This data is offered solely for your consideration, interpretation, and information.

Date: May, 1985

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INSTRUCTIONAL SUPPLEMENT #2 — Potting Compound Data

PREFERRED POTTING COMPOUND

COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
(Stiff mix)		
EPON 815	100	37
MICROBALLOONS	30	100
CURING AGENT "T" (ANCAMINE "T")	22	10
(Average mix)		
EPON 815	100	37
MICROBALLOONS	24	63
CURING AGENT "T" (ANCAMINE "T")	22	10
(Thin mix)		
EPON 815	100	37
MICROBALLOONS	16	50
CURING AGENT "T" (ANCAMINE "T")	22	10

NOTE

Epon 815 with the correct amount of microballoons and curing agent "T" is available in separate compartments in a flexible plastic container, part Nos. 80055-44 and -45, manufactured by Fenwal Laboratories Inc., Framingham, Massachusetts. If the plastic containers are not available, the proper mix may be obtained using the following procedure.

MIXING PROCEDURE

1. Select the desired mix.

NOTE

The stiff mix is desirable when conducting overhead repairs or for core plug bonding. The average mix or the thin mix is desirable when conducting upper surface repairs.

2. Add microballoons to the Epon 815 and mix for 3 to 5 minutes.
3. Add curing agent "T" to the Epon 815 microballoon mixture and mix for 3 to 5 minutes.

Source: United States Air Force.

Epon 815. Epon 815, used with microballoons and curing agent "T," is used as a metal-to-metal bonding adhesive because of its ambient temperature curing characteristics. This adhesive can be obtained in small flexible, plastic, throw-away bottles. The throw-away bottles contain the adhesive mixed with the microballoons and curing agent in a small flask. When using the throw-away bottles, break the small curing agent flask by squeezing, then knead the curing agent into the adhesive until thoroughly mixed. The mixture must be used within 20 minutes after breaking the curing-agent flask.

Conventional-type mixing requires that the microballoons be added to the Epon 815 and stirred thoroughly until no lumps are visible for approximately 5 to 10 minutes. After they are mixed, add the curing agent (T) and stir until completely dispersed, approximately 3 to 5 minutes. Curing agent "U" can be substituted for curing agent "T". Also the adhesive can be used without the use of microballoons if microballoons are not available. The cure time for the Epon 815 mixture will decrease as heat is applied. At room temperature, the cure time is 4 hours. With the increase of heating temperature up to 200° F, the cure time is reduced to 30 minutes. After the repairs have been coated with adhesive and clamped in place, apply a low pressure until the repair has cured.

Mixture-Type Potting Compounds. A commonly used potting compound consists of a mixture of Epon 815 (low-viscosity liquid resin) and curing agent "T" with microballoons added in required amount to control the viscosity (thickness) of the mixture. The added microballoons have no curing effect on the mixture. This compound has a bench or pot life of 15 to 20 minutes and a cure time of approximately 4 hours at room temperature (70° F). An alternate mixture consists of equal parts of Epons 812 and 815 and Versamids 115 and 125, to which microballoons are also added. This alternate compound has a pot life of 2 hours and a cure time of 12 hours at room temperature (70° F) or 1 hour when heated. Epon 815 and curing agent "A" can be used as a potting compound when microballoons are added.

Source: United States Air Force.

INSTRUCTIONAL SUPPLEMENT #2

ALTERNATE POTTING COMPOUND

COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
RF 2500 (Resin)	100	83
EPON 828	100	83
VERSAMID 115 (V-15) (Hardener)	100	100
VERSAMID 125 (V-25) (Hardener)	100	100
MICROBALLOONS	80	880

MIXING PROCEDURE

1. Add Epon 828 to RF 2500 and mix thoroughly.
2. Add Versamid 115 to Versamid 125 and mix thoroughly.
3. Add resin mixture to Versamid mixture and mix thoroughly.
4. Add microballoons to resin-Versamid mixture and mix thoroughly.

NOTE

Epon 812 may be used in place of RF 2500 until existing stocks are depleted. RF 2500 is a direct substitute for Epon 812.

HOLE DIAMETER	GRAMS OF PREFERRED POTTING COMPOUND REQUIRED (APPROX)	GRAMS OF ALTERNATE POTTING COMPOUND REQUIRED (APPROX)
.50	3	5
.75	6.5	10
1.00	11	18

Amount of Potting Compound Required
For One-Inch-Deep Hole

Source: United States Air Force.

INSTRUCTIONAL SUPPLEMENT #2

Glass Cloth Adhesives. A commonly used glass cloth adhesive is a mixture of equal parts of low-viscosity liquid resins (Epon 812 and Epon 828) with equal mixture by weight of curing agents (Versamid 115 and Versamid 125). Mixing procedures for a batch mix is as follows: mix equal parts (by weight) of the Versamids, then mix the Epons and the Versamids together. A batch mix containing 20 grams (.04 lbs) yields the necessary quantity of adhesive to bond two 6-inch-diameter layers of glass cloth. This mixture has a pot life of about 2 hours and will cure in 12 hours at room temperature (70° F). When heat is applied (130° F), the cure time is reduced to one hour.

Two types of hot-bond glass cloth adhesives can also be used. One consists of Epon VIII plus Epon 828 and curing agent RP-7; the other consists of Epon VIII and curing agent "A". Both of these adhesives have a pot life of approximately 2 hours at 75° F. However, at any time after the adhesives have been mixed, should it become too thick to apply easily, discard and prepare a new batch. Curing temperature and times for these glass cloth adhesives are shown below.

TEMPERATURE (F°)	MINIMUM TIME
160 ± 10	16 hrs
200 ± 10	1½ hrs
240 ± 10	30 minutes

NOTE

Epon VIII and curing agent "A" can also be used to bond honeycomb plugs in place

Source: United States Air Force

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INSTRUCTIONAL SUPPLEMENT #2

GLASS CLOTH ADHESIVE DATA

COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
EPON 812	100	83
EPON 828	100	83
VERSAMID 115	100	100
VERSAMID 125	100	100

NOTE

Mixture pot life is approximately 2 hours at 70° F (21° C). Cure time is approximately 12 hours at 70° F (21° C) or 1 hour at 130° F (54° C).

MIXING PROCEDURE

A batch mix containing 20 grams (.04 lbs) yields the necessary quantity of adhesive to bond two 6-inch-diameter layers of glass cloth.

1. Add Epon 828 to Epon 812 and mix thoroughly.
2. Add Versamid 115 to Versamid 125 and mix thoroughly.
3. Add Epon mixture to Versamid mixture and mix thoroughly.

NOTE

Epon 812 and Epon 828 with the correct amount of versamids and two 6-inch fiberglass disks are available in separate compartments in a flexible plastic container, part no. 80055-78. Manufactured by Fenwal Laboratories Inc., Framingham, Massachusetts.

Source: United States Air Force.

INSTRUCTIONAL SUPPLEMENT #2

EPON 815 EPON 828 (Resin)	Shell Chemical Corp. P.O. Box 1422 Houston, TX 77251
CURING AGENT "T" (Ancamine "T")	Pacific Anchor Los Angeles, CA 90040
PHENOLIC SPHERE (Microballoons)	V.C.A.R. Coatings/Resins P.O. Box 181 Boundbrook, NJ 08805
VERSAMID 115 (V-15) VERSAMID 125 (V-25)	Henkel Corp. Kankakee, IL General Office Minneapolis, MN 55440
RF 2500 (Resin)	Resin Formulator's Co. Div. of E.V. Roberts 8500 Stiller Drive Culver City, CA 90232

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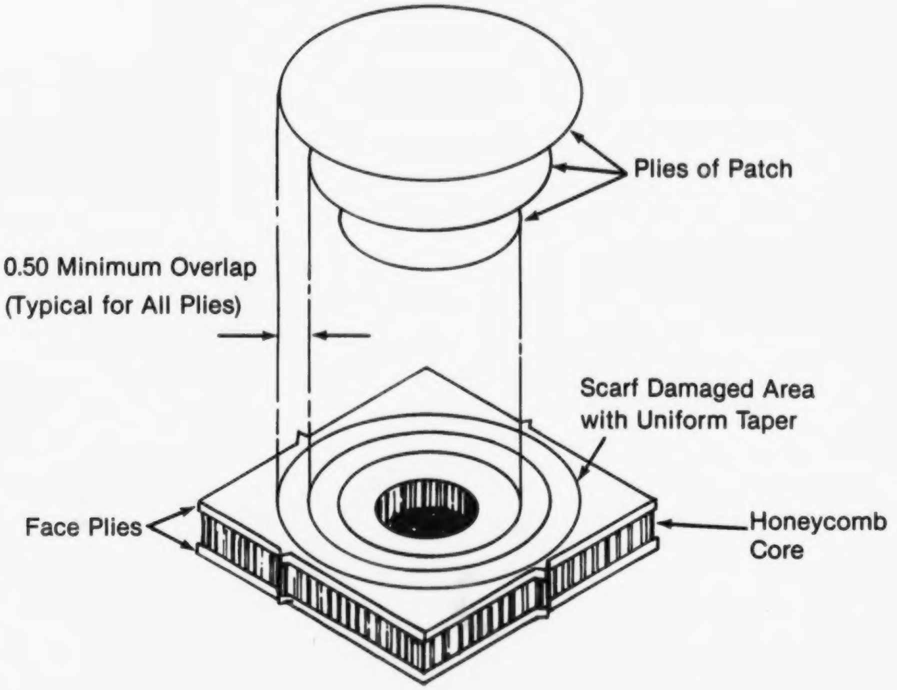
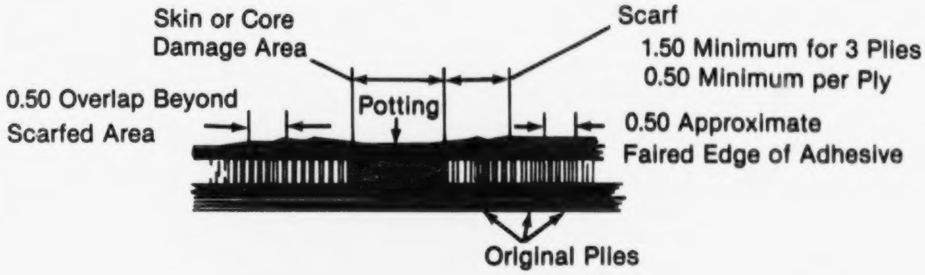
INSTRUCTIONAL SUPPLEMENT #3 — Scarf Method for Fiberglass Bonded Structure

BOEING 727

FOR TRAINING PURPOSES ONLY

STRUCTURAL REPAIR


Plies of Patch
0.50 Minimum Overlap
(Typical for All Plies)
Scarf Damaged Area
with Uniform Taper
Face Plies
Honeycomb
Core


Skin or Core
Damage Area
Scarf
1.50 Minimum for 3 Plies
0.50 Minimum per Ply
0.50 Overlap Beyond
Scarfed Area
Potting
0.50 Approximate
Faired Edge of Adhesive
Original Plies

Section Through Repair

Used with permission of Boeing Commercial Airplane Company, Seattle, Washington.

INSTRUCTIONAL SUPPLEMENT #4 — Router and Template: Usage in Fabrication

FOR TRAINING PURPOSES ONLY

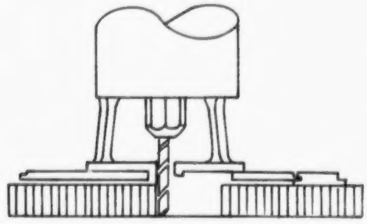
STRUCTURAL REPAIR

NOTES

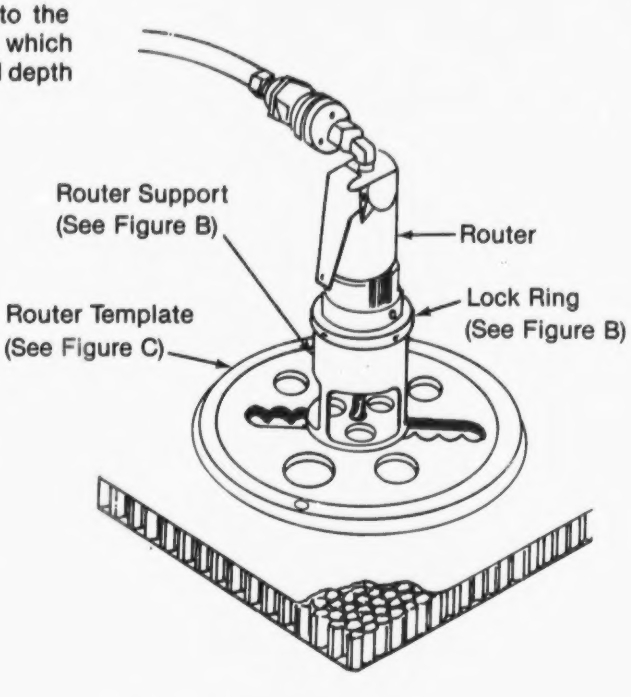
WARNING: Use face shield or goggles when working with router.

- This router assembly is used to remove damaged core and skin in flat honeycomb panels.
- The power router must be explosion-proof. The suggested "ACORNAD-1" router is air-powered.
- The router is kept perpendicular to the repair surface by a router support which can be adjusted to give the desired depth of cut.
- A suitable template has to be used in order to trim the damage to a smooth outline. Plywood templates with rounded holes of the desired size and shape may be made for this purpose. A metal template for cutting circular holes of various sizes is detailed in Figure C, designed for use with a ¼-inch router bit in the power router.

FIGURE A

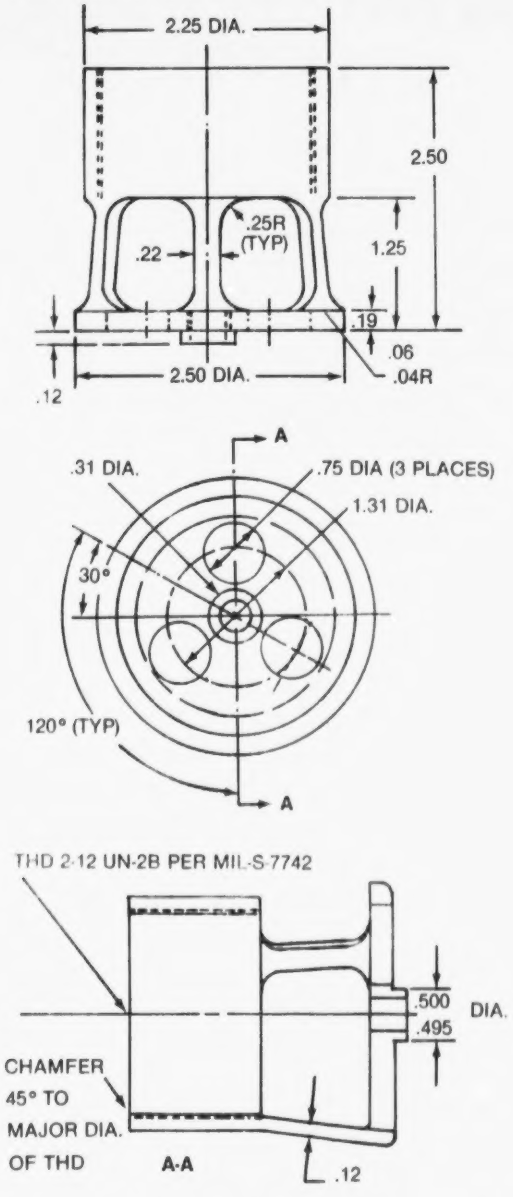


Side View

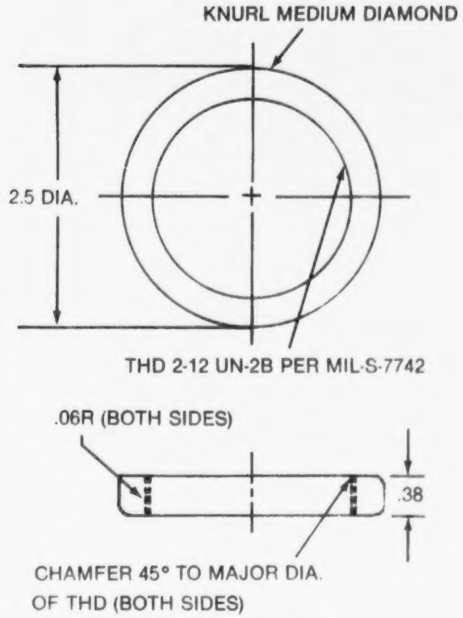


STRUCTURAL REPAIR

FIGURE B


2.25 DIA.
2.50
1.25
.25R (TYP)
.22
.19
.06
.04R
2.50 DIA.
.12
A
.31 DIA.
.75 DIA (3 PLACES)
1.31 DIA.
30°
120° (TYP)
A
THD 2-12 UN-2B PER MIL-S-7742
.500
.495
DIA.
CHAMFER 45° TO MAJOR DIA. OF THD
A-A
.12

Support Base Assembly


KNURL MEDIUM DIAMOND
2.5 DIA.
THD 2-12 UN-2B PER MIL-S-7742
.06R (BOTH SIDES)
.38
CHAMFER 45° TO MAJOR DIA. OF THD (BOTH SIDES)

Lock Ring

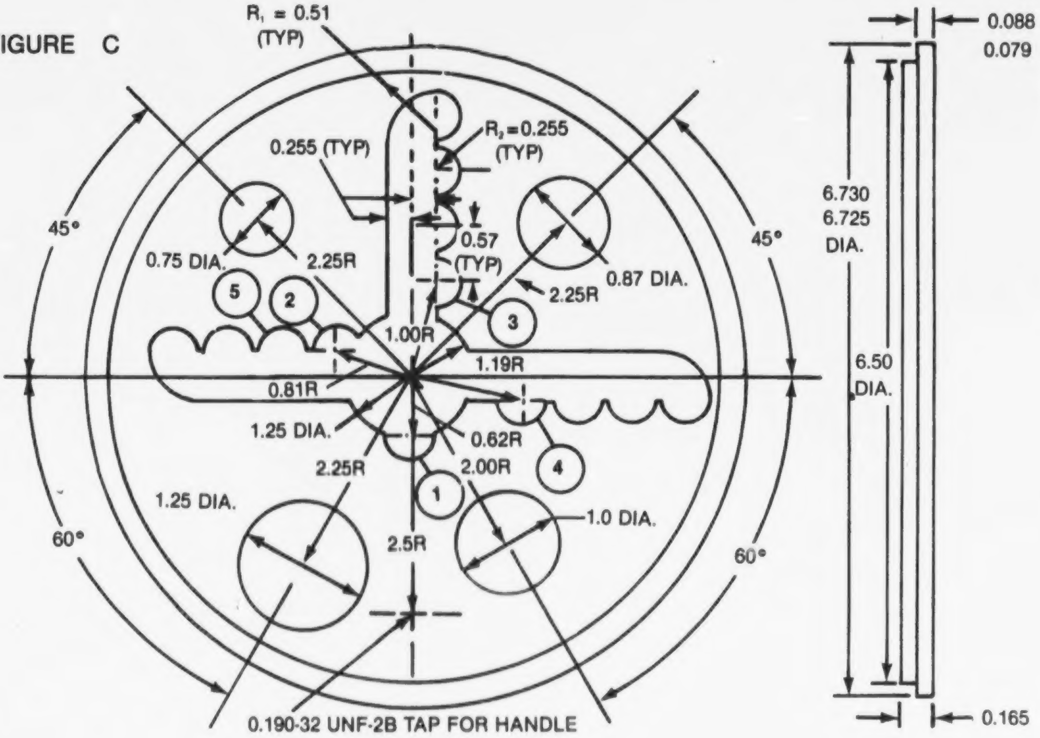
NOTE

This router base and lock ring is for use with the router shown in Figure A that is fitted with special 2-12UN-2A threaded sleeve.

Material SAE 1919 STEEL (SAE 1013, 1020, ASTM A7-50, or AISI-C-1018 optional)

AMSI corrosion resistant steel casting optional.

FIGURE C


R1 = 0.51 (TYP)
R2 = 0.255 (TYP)
0.255 (TYP)
0.57 (TYP)
45°
45°
0.75 DIA.
2.25R
0.87 DIA.
2.25R
5
2
3
1.00R
1.19R
0.81R
1.25 DIA.
0.62R
2.25R
2.00R
4
1
1.25 DIA.
1.0 DIA.
60°
2.5R
60°
0.190-32 UNF-2B TAP FOR HANDLE
0.088
0.079
6.730
6.725
DIA.
6.50
DIA.
0.165

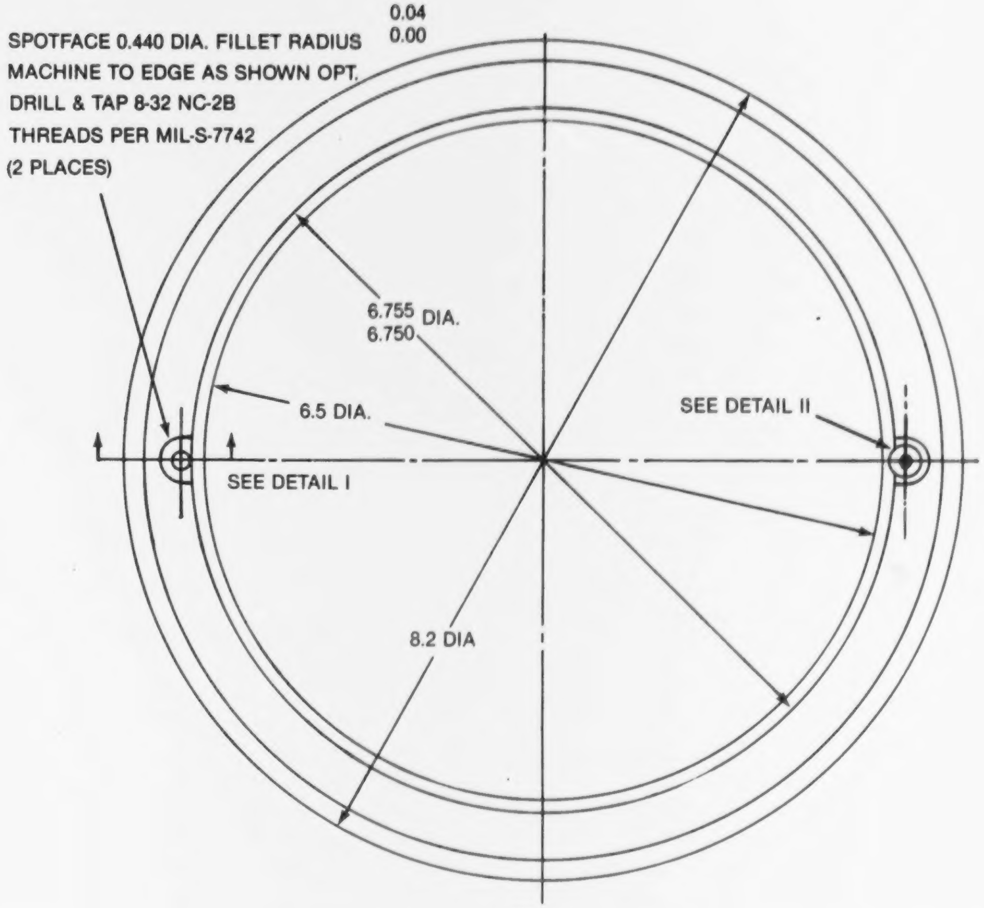
Router Template

NOTES

- This template is designed to guide the power router assembly illustrated in Figure A while cutting out damage to a circular outline with a ¼-inch router bit.
- Both the template and ring can be fabricated of SAE 1010 steel (SAE 1015, 1020, ASTM A7-50, or AISI-C-1018 Optional).
- The 4 circular holes in the template can be used to rout holes up to 1 inch diameter.
- To rout out larger damage, center the template ring over the damage and tape it to the honeycomb panel with masking tape. The template turns freely within the ring. The head of the 2 screws prevents the template from coming out of its seat.

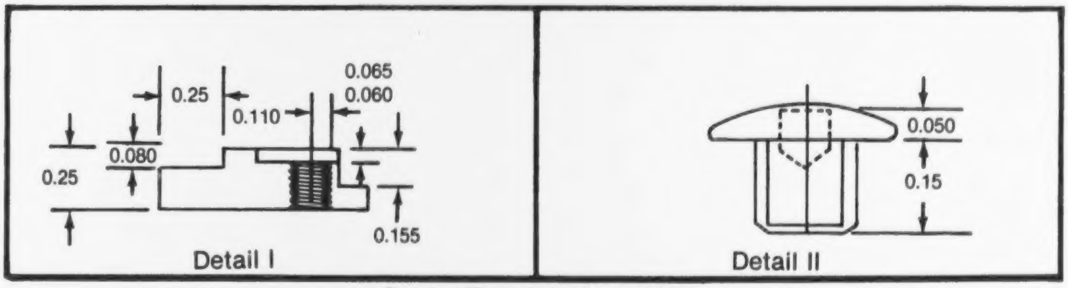
Start routing from the center. Place the guide of the router base in Slot 1, start the router and rotate the template clockwise while routing. A handle may be inserted in the tapped hole to facilitate rotation of the template within its seat. After completing a circle with router in Slot 1 proceed to Slots 2, 3 and so on in the indicated sequence until all damage has been routed out.

STRUCTURAL REPAIR


SPOTFACE 0.440 DIA. FILLET RADIUS
MACHINE TO EDGE AS SHOWN OPT.
DRILL & TAP 8-32 NC-2B
THREADS PER MIL-S-7742
(2 PLACES)

0.04
0.00
6.755
6.750 DIA.
6.5 DIA.
SEE DETAIL II
SEE DETAIL I
8.2 DIA

Ring


0.25
0.110
0.065
0.060
0.080
0.25
0.155
Detail I
0.050
0.15
Detail II

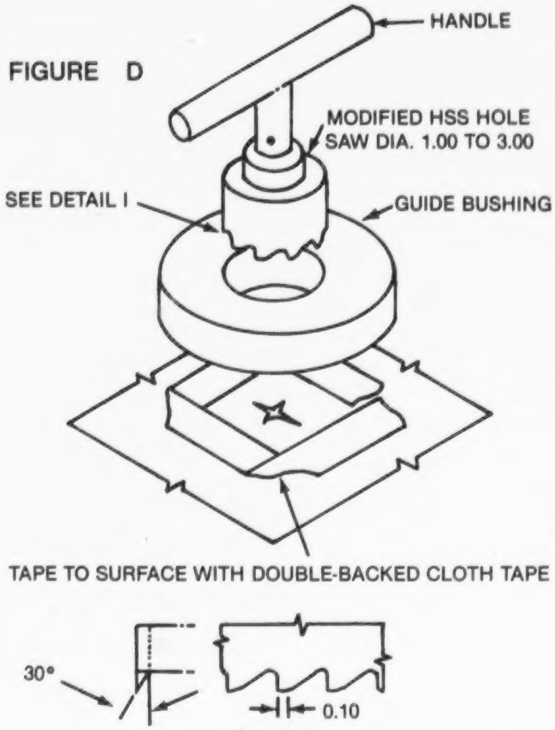
Router Template Assembly

INSTRUCTIONAL SUPPLEMENT #4

FOR TRAINING PURPOSES ONLY

STRUCTURAL REPAIR

FIGURE D


HANDLE
MODIFIED HSS HOLE SAW DIA. 1.00 TO 3.00
SEE DETAIL I
GUIDE BUSHING
TAPE TO SURFACE WITH DOUBLE-BACKED CLOTH TAPE
30°
0.10

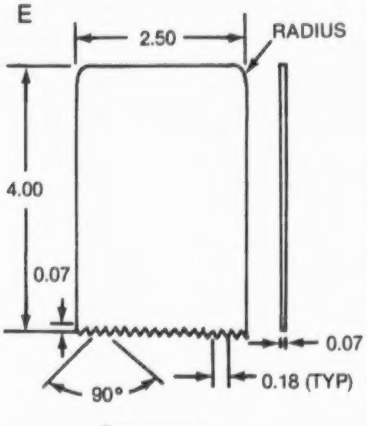
Detail I

Hole Saw

NOTES

- This hole saw is used for trimming damaged aluminum skin of honeycomb panels to a circular outline. Recommended sizes of this tool are 1-inch, 2-inch and 3-inch diameter. For these sizes it is an alternate tool to the power router shown in Figure A.
- This hand tool is a modified high-speed stell hole saw with a handle. The hole is cut by turning the tool within a guide bushing which is attached to the repair surface with double-backed tape.
- The guide bushing can be fabricated from 0.75 inch thick aluminum alloy stock with a hole corresponding to the diameter of the hole saw.
- During use keep the hole saw perpendicular to the repair surface, lateral pressure will shift the guide bushing.

FIGURE E


2.50
RADIUS
4.00
0.07
0.07
90°
0.18 (TYP)

Squeegee

NOTES

- Make this squeegee from 0.07 inch Plexiglas or equivalent material.
- The notched edge of the squeegee can be used for spreading adhesive and the smooth edges for impregnation of fiberglass cloth patches.

Instructional Supplement #4 used with permission of Boeing Commercial Airplane Company, Seattle, Washington.

TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Filament — Single thread

B. Thermoplastic resin — Resin material which will soften with the application of heat

(NOTE: Most aircraft windshields and side windows are made of this material.)

C. Thermosetting resin — Resin that usually sets by chemical means and maintains its hardness even when heat is applied

D. Bonded structure — Structure whose parts are joined together by chemical methods rather than mechanical

E. Honeycomb — Hexagonal cellular material made of thin metal, paper, or plastic; used as a core material for sandwich structure

(NOTE: It is named after the bee's honeycomb because of its appearance.)

F. Laminated — Composed of thin layers of material firmly bonded or united together

G. Cure — Chemical change which takes place in a finishing system which produces the desired surface

H. Fiberglass — Extremely thin fibers of glass used to reinforce epoxy or polyester resin for aircraft structure

(NOTE: Fiberglass may be woven into a cloth or lightly packed into a mat.)

I. Polyester resin — Synthetic resin, usually reinforced with fiberglass cloth or mat, used to form complex shapes for aircraft structure

J. Catalyst — Material which is used to bring about a change, but does not actually enter into the change itself

K. Inhibitor — Agent added to a resin to retard its curing and increase its shelf life

L. Accelerator — Substance added to a catalyzed resin to shorten the time required for the resin to cure

M. Epoxy resin — Flexible thermosetting resin made by polymerization of an epoxide; used chiefly in coatings and adhesives

N. Curing agent — Substance which combines with epoxy resin to initiate the curing of the material

O. Toxic — Poisonous

P. Thixotropic agent — Substance added to resin to increase its resistance to flow

Q. Release agent — Substance used on a mold to prevent bonding of the resin to the mold

R. Delamination — Separation of the core and face sheets of a bonded structure along a bond line

S. Shelf life — Time span a plastics product will remain fit for use

(NOTE: Temperature during storage is a prime factor of shelf life. "Shelf life" is sometimes referred to as *storage life*.)

T. Cohesion — Sticking together of particles of a substance held together by valence forces

EXAMPLE: Water in a glass of water, if filled to the rim, can be observed protruding over the rim slightly

U. Pot life — Length of time at room temperature before a catalyzed resin has polymerized (hardened) to an unworkable state

V. Film adhesive — Adhesive in sheet-like form that comes in various thicknesses with a backing film, heat cured

W. Fiber — Single homogeneous strand of material; used as the principal constituent in advanced composite

X. Fiber direction — Orientation or alignment of the longitudinal axis of the fiber with respect to a stated reference axis

Y. Composite — Combination of distinct parts which are put together to form a compound

EXAMPLE: Kevlar skin and aluminum honeycomb core bonded together with an adhesive

Z. Solvent — Substance, usually a liquid, used for dissolving/cleaning materials during reinforced plastics operations

AA. Acetone — Volatile liquid used as a solvent for organic compounds

BB. Adhesion — Adhering or sticking together of substances in contact with each other

CC. Adhesive — Glue, paste, or film-type substance that when applied to two matting surfaces is capable of holding them together by surface attachment

DD. Paste adhesive — Adhesive in container form, usually a two- or three-part mix, applied with brush or spatula, air or heat cured

EE. Gel — Stage when a polymerizing resin composition thickens to a semisolid form

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TECHNICAL INFORMATION SUPPLEMENT #2 — Safety

WARNING

Fiberglass dust or minute particles of composite material are harmless in appearance, but they are actually small, many-faceted particles. These particles are extremely harmful when breathed and are a very annoying irritant when in contact with the skin. Cured graphite particles are barbed on their ends, making removal of these particles from flesh extremely difficult.

Dust from composite materials will form a mass in the lungs if inhaled, causing severe lung damage. Wearing protective clothing, gloves, and the appropriate type of respirator will ensure that this does not happen to you.

The following is a list of safety rules to be observed when working with fiberglass and metal bonded structure.

A. Avoid breathing dust and chemical fumes from composite materials, and wear an approved respirator when grinding, sanding, or working around composite material or any type of work involving chemicals

B. Wear protective clothes and discard when finished grinding or sanding

C. Work in a manner that will produce a minimum amount of dust

D. Work in a well-ventilated area

(NOTE: This will help to prevent dust and fumes from making you sick, and it will also help to reduce explosive hazards.)

E. Use the proper type of eye and face protective apparel

WARNING

The use of a chemical face shield is required for certain operations.

F. Use the proper type of protective cream or gloves for your hands

G. Wear a face mask and ear plugs when routing

H. Have ready access to appropriate fire-fighting equipment

I. Know the chemicals you are working with; if they are not labeled, DO NOT use them

WARNING

Mixing the wrong chemicals could result in an explosion.

J. Dispose of flammable wastes and reusable shop rags contaminated with chemicals in fireproof containers

K. Use only explosionproof lights in repair or fabrication areas

> **WARNING**
>
> **Be sure all electrical systems and equipment meet all federal code requirements.**

L. Use an explosive meter to monitor areas where chemical fumes concentrate

M. Never use a chemical without first consulting the safety data sheet and the container label

(NOTE: If you do not understand both the safety data sheet and the container label, check with your instructor.)

N. Make sure metal bonding materials are segregated from composite bonding materials

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TECHNICAL INFORMATION SUPPLEMENT #3 — Materials Used in Fiberglass and Composite Bonded Structure Construction and Repair

A. Resin — Used to give repair hardness and produce the bond

1. Polyester resin system — Resin system used strictly for mat molded fiberglass parts and laminated glass cloth stuctures including fiberglass honeycomb enclosures

2. Epoxy resin system — Resin system commonly used as adhesives that when mixed produce a liquid that will flow between the fiberglass; produces a hard, plastic-like surface when cured

3. Phenolic resin system — Resin system used to stabilize the core of nylon honeycomb

B. Accelerator — Chemical compound used in a polyester resin mixture to speed up or hasten the chemical reaction caused by addition of the catalyst (sometimes called a promoter)

C. Catalyst — Chemical compound usually added last to a polyester resin mixture to cause it to harden

D. Types of fiberglass used to reinforce resins (give the repair its strength)

1. Woven glass cloth — Glass which is spun into yarn and then made into glass fabric; has the texture and look of wool cloth, but has a glassy appearance like satin

   Most dominate kinds of fiberglass cloth used in the repair of fiberglass and metal bonded honeycomb assemblies are:

   a. Scrim cloth — like cheesecloth
   b. #128 Volan "A" finish
   c. #181 Volan "A" finish
   d. #191 Volan "A" finish

2. Chopped fibers — Short, loose fibers that are mixed directly into the resin and are useful in areas that have complicated shapes; made from fiberglass material and used most often for molded constructions

3. Mat binder — Material that looks like two- to three-inch white strands pressed to form a loose blanket; the strands have no pattern, and in uncured stage looks quite porous

E. Parting/release agents — Materials that will not bond to the resin as it cures

1. Polyvinyl alcohol (PVA film) — Water-soluble plastic material used as a parting agent during the curing process; it can be easily removed from the repair when necessary

   (NOTE: This is used with polyester resin only.)

2. Polyethylene (PE) film — Plastic film used on overlays and where pressure may not be applied; will not stand up to high heat, is not affected by moisture, and will not stretch as easily as PVA

   (NOTE: This is used with epoxy resins only.)

F. Thixotropic agent — Agent added to resins in required amounts to control the viscosity

EXAMPLES: Mill fibers, microballoons

G. Paint removers and cleaners — Materials used to expose the surface and give visual access to underlying plies

EXAMPLES: MEK, acetone

WARNING

Acetone and methyl ethyl ketone solvents are toxic and are extreme fire hazards. DO NOT use these materials in confined areas without ventilation. Wear neoprene gloves for protection of hands.

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TECHNICAL INFORMATION SUPPLEMENT #4 — Materials Used in Metal Bonded Honeycomb Repair and Their Correct Uses

A. Glass fabric — Cloth woven from fibers made of spun glass which is used in overlay repairs to bonded honeycomb structures

B. Potting compound — Type of compound used to repair bonded honeycomb structures; holes up to one inch in diameter are sometimes repaired by using this material in a process called a *hole-filling technique*

C. Primer — Material sprayed on bonded honeycomb repair areas for protection against erosion and corrosion

D. Corrogard (EC843) — Aluminum pigmented erosion and corrosion preventive which can be either sprayed or brushed on bonded honeycomb repairs

E. Adhesive primer — Primer used on metal surfaces to be bonded; works with adhesive to create a better bond

EXAMPLE: EC 776

F. Duxseal sealing compound — Sealing compound used around a hole to be repaired in a bonded honeycomb structure; acts as a reservoir to ensure adequate filling with potting compound

G. Polyethylene (PE) film — Parting agent used with epoxy resins only

H. Type 38 adhesive — Epoxy resin system used with fiberglass cloth when fabricating overlay repair to metal bonded honeycomb

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TECHNICAL INFORMATION SUPPLEMENT #5 — Types and Characteristics of Bonded Structures

A. Fiberglass assemblies

Fiberglass is glass. It is made from balls of glass that are heated and spun into strands or drawn into fibers.

The three main forms of raw fiberglass are woven glass cloth, chopped fibers, and mat binder. It is important to know that there is a difference between fiberglass structures and the forms of raw fiberglass. These raw fiberglass forms must be mixed with a resin to make them a structure or fiberglass assemblies such as preformed fiberglass, laminated fiberglass, or sandwich construction. Resin is a liquid plastic—when it hardens, it is plastic. When fiberglass and resin are combined, they are stronger than the fiberglass and the cured resin separately. The resin will cause the structure to have most of the characteristics of plastic. The desired condition requires cohesion between the plies. This is achieved by proper combination of the glass fibers and resin.

A fiberglass assembly will weigh about the same as glass. When it is tapped, it will sound like glass. It will stand up to the same high temperature that glass will, but because it is made from fibers, it does not break like glass. It might crack, but it will not shatter. The fibers make it stronger than plain glass. It is easier to form to complicated shapes than most materials.

A fiberglass assembly has a longer service life, does not corrode, and is resistant to most metals. It is a lot easier to form to most shapes. It is much better to use than metal where electrical wave transmission is needed, yet it retards electrical current flow. It is stronger than most metals.

Fiberglass is used to make many kinds of aircraft parts such as electrical junction boxes, battery boxes, wing tips, tanks, antenna covers, and instrument panels, and is used to make repairs to metal or fiberglass surfaces.

It is used on those parts of the aircraft where there is a need for radio or radar waves to pass through. It is also used in farings for increased aerodynamic efficiency. At the same time, it must have the same strength as the metal around it.

1. Preformed — These assemblies are made with chopped strands of glass placed on a screen of a mold shape. They are bonded together with a resin and cured under heat and pressure. The glass fibers act as a reinforcement for epoxy or polyester resins.
2. Mat molded — It is much the same as preformed, except the pattern is cut from a flat mat of glass fibers.

   (NOTE: Both mat molded and preformed assemblies are used for nonstructural parts such as ducts, relay shields, etc.)

3. Solid laminate — This type of construction has two or more layers of glass cloth bonded together with resin under heat and pressure. It has greater strength than molded assemblies and is used for antenna housings, navigation and radar equipment, and other structural parts.

4. Sandwich construction — This type of structure is strong, rigid, and lightweight. It has a core to which face plies of glass cloth are bonded. The core separates the face plies and gives the panel strength and makes it stiff. The core may be made from any material, but for now only fiberglass core will be discussed.

B. Hybrid and composite materials

Composites differ from metals. Composites are combinations of materials differing in composition or form. Although they act together, composite materials do not dissolve or merge as do metals when they are alloyed.

Advanced composite materials consist of high-strength fibers embedded in a resin matrix. Composites offer the potential for major weight savings in airplane design. They have high strength-to-weight ratios. When replacing aluminum structure with graphite/epoxy composite structure, weight reductions of 20 percent or better are common. Weight reduction is the greatest advantage of composite material and is one of the key items in decisions regarding its selection.

One of the other interesting aspects of the high performance reinforcement development is the blending of various materials to develop further performance factors. At the present, one of the most interesting applications is the blending of graphite and Kevlar fibers (Du Pont). Kevlar fibers are produced synthetically by Du Pont and have the highest specific strengths of all the reinforcements. Kevlar suffers drastically under compressive loads and has, therefore, been used mainly in developmental studies. A single yarn of yellow Kevlar is currently woven into current graphite fabrics to provide the directions of the warp and fill of the material.

Section B used with permission of American Airlines, Tulsa, Oklahoma

C. Metal bonded honeycomb

This is a laminar construction consisting of a combination of alternating dissimilar material, assembled and fixed in relation to each other so the properties of each can be used to attain specific structural advantages for the whole assembly.

The development of metal bonded honeycomb structures was the beginning of a new era in aircraft engineering. This technique provides a strong, lightweight structure that is more aerodynamically smooth than older types of structure. Engineers are still experimenting with different combinations of core material and facings to improve upon the original design. Airframe repair specialists have the responsibility of maintaining and repairing metal bonded honeycomb structures. In some instances, you may be called upon to rebuild entire panels. Therefore, it is important that you become familiar with the construction features of metal bonded honeycomb structures and with the procedures used to locate and repair damaged areas.

TECHNICAL INFORMATION SUPPLEMENT #5

1. Sandwich constructed assemblies — Used on modern aircraft for areas such as bulkheads, control surfaces, fuselage panels, wing panels, empennage skins, and shear webs

    a. Has superior strength-to-weight ratio over conventional structures

    b. Is better able to withstand sonic vibrations

    c. Has relatively low cost when compared to conventional structure

    d. Increases aerodynamic smoothness

    (NOTE: Special applications of metal bonded honeycomb may be made from various combinations of stainless steel, titanium, magnesium, plywood, resin impregnated paper, glass, nylon, and cotton.)

    Metal bonded honeycomb structures are made by bonding a core between two face plies. This is called metal bonded because either the core or the facings are made of metal.

2. Construction characteristics

    a. Assembly — The three areas found on honeycomb panels are the bay area, the transition area, and the flange area.

    b. Bay area — The large flat part of the panel in the middle is known as the bay area.

    c. Transition area — The area between the bay area and the edge of the panel or flange area is known as the transition area. It may be rounded or tapered in shape.

    d. Flange area — The edges of the panel where it is attached to other structures is known as the flange area.

    e. Doubler — A doubler is used to add strength to the flange area.

    f. Facings — A metal bonded honeycomb assembly has two facings. These are known as the inner and outer skins. These face plies are the load-carrying parts of the structure. The skin may be made of aluminum, stainless steel, titanium, and most types of steel and aluminum alloys. The most commonly used alloys are 2024-T3 and 7075-T6.

    g. Core — The term *honeycomb* is used used because the hexagonal shape of the core resembles the hive in which bees store their honey. The geometric shape of the cells produces the necessary strength in the structure. The lightness is a result of the hollow structure. The void in each cell produces the good insulating qualities. Core material is made by the corrugation process or by the expansion process. The two types of core are perforated and nonperforated.

h. Scrim cloth adhesive — This adhesive is used in metal bonded honeycomb structure that uses scrim cloth to provide adhesive support and wicking of the solvents to the atmosphere surrounding the bonding part.

i. Corrugation — Corrugated core is made by forming thin foil strips into what is known as a ribbon. The ribbon is formed by a machine that presses the foil into the shape of half of a hexagon. Then the ribbons are placed side by side and are bonded together to form the honeycomb core material.

j. Expansion — The other method used to make core is called the expansion process. The end product of this process is called "HOBE". HOBE stands for "Honeycomb Before Expansion". Strips of foil are stacked with an adhesive applied between the strips at given intervals. The cell size is determined by where the adhesive is placed. The core is shipped to the user in this compressed condition. When the user is ready to make use of the HOBE, the user places it in a machine that expands or stretches it to the desired cell size. One advantage of HOBE over the corrugated form of honeycomb core is that it may be shipped and handled with little or no damage to the cells, and it is also highly machinable.

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TECHNICAL INFORMATION SUPPLEMENT #6 — Procedures for Inspecting Fiberglass and Composite Bonded Structure

A. Visually inspect plastic assemblies

1. Remove any surface coatings which hinder visual inspection

2. Evaluate the extent of damage further by using a strong light source

   (NOTE: The damaged portion may be identified by a dissimilar appearance in the presence of a strong light source.)

B. Tap test reinforced plastic assemblies for bond damage

(NOTE: A heavy coin is suitable for the tap test. It is recommended to use a quarter held between the thumb and forefinger. Some slight change in tapping sounds can be heard when comparing honeycomb bonded and solid laminate lay-up structures.)

1. Lightly tap damaged area and listen for change in sound

   (NOTE: A sharp, clear sound defines no bond damage. A dull, flat sound defines a void or bond damage.)

   CAUTION

   Tap lightly to avoid denting or damaging thin outer facing.

2. Tap test suspected damaged area until damage borders are defined

C. Perform nondestructive inspection

EXAMPLES: Ultrasonic and x-ray inspections

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TECHNICAL INFORMATION SUPPLEMENT #7 — Classes of Fiberglass Bonded Honeycomb Repairs

Damages to sandwich parts are divided into groups or classes according to the severity and possible effect upon the structure of the aircraft and upon electrical efficiency.

A. Class I repair — Damage affecting the outer ply only

   1. Scars — Damage from handling, storage, removal, or installation

   2. Scratches — Damage from handling, storage, removal, or installation

   3. Erosion — Damage from weather conditions

   4. Installation — Edges of radome sanded to fit mounting frame

B. Class II repair — Damage to one facing only, possibly accompanied by damage to the core

   1. Punctures — Damage extending through at least one ply of the radome and possibly into the core

   2. Delaminations — A separation between the plies or laminations

      (NOTE: Delamination can be caused by moisture and/or oil contamination.)

   3. Contaminations — Moisture and oil contamination can cause damage to the radome

      (NOTE: Either oil or moisture contamination can cause very serious degradation of the performance of the aircraft radar system, core weakening of the radome facing, and weakening of the facing-to-core bonding strength.)

   4. Fractures — A crack or break in one facing only, possibly accompanied by damage to the core

C. Class III repair — Damage extending completely through the sandwich affecting both the facings and the core

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TECHNICAL INFORMATION SUPPLEMENT #8 — Inspection and Classification of Damage to Metal Bonded Honeycomb Structures

(NOTE: Inspection for damage is more critical for honeycomb assemblies than for conventional structures because honeycomb structures can suffer extensive damage with no observable indication.)

A. Delamination — A separation of the bond between the core and the outer or inner skin

   1. Visual or thumb-pressure test — Occasionally the delaminated skin will oilcan away from the core, making visual or thumb-pressure detection possible.

   2. Tapping method — The tapping method is an easy and effective way to test voids or delaminations in the bond. This is also known as the *metallic ring test*. All you need is a small metal piece such as a coin (25-cent piece). If the area has a good bond, the tone given off will be a metallic ring. If the facings have separated from the core, the tone given off will be a low, dull thud. This is not the best method of inspection, but it is effective in some preliminary checks. If an area that gives off a dull thudding sound is found, it should be further inspected by nondestructive inspection (NDI).

B. Puncture, dent, and crack inspection

   1. Conventional methods — Visual inspection would usually detect punctures, dents, and cracks

C. Scratches — These should be given special attention. With such thin material as that used in metal bonded honeycomb, cracks often appear to be scratches.

   1. Visual inspection — Visual inspection is a quick and easy way to find those types of damage that can be seen with the eye. Holes, tears, and gouges may be seen from the outside of the panel. However, you cannot see what has happened to the inside of the assembly, so other methods must be used to find damage that is not visible to the eye.

   2. Caustic soda solution test — Scratches on aluminum surface panels can be tested with caustic soda solution. If the scratched area turns black after the application of a small amount of solution, the scratch has penetrated the clad surface.

D. Nonstandard bonds, voids, and other similar defect inspection

   1. Panel inspection analyzer — Sometimes referred to as stub meter or coindascope

E. Wing understructure inspection

1. Inspection boroscope — An electronic device designed to detect wing understructure damage

F. Damage evaluation

(NOTE: This is the system used by the United States Air Force.)

1. Class I damage — Dents, nicks, and scratches to the skin that do not penetrate through the skin or cause delaminations
2. Class II damage — Holes, tears, and gouges; includes delaminations and cracks in the skin, providing that the core is not damaged
3. Class III damage — Damage to one skin and the core
4. Class IV damage — Damage to both skins and the core

Damage to aluminum honeycomb structures can vary from minor dents or scratches to total panel destruction. Damage evaluation charts for honeycomb structures can be found in the applicable section of the structural repair manual for the specific aircraft. The charts specify types of damage, allowable damage, damage requiring repair, and figure numbers that illustrate similar repairs for each type of damage.

Once the type of repair is determined, procedures outlined in the structural repair manual should be rigidly followed.

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TECHNICAL INFORMATION SUPPLEMENT #9 — Methods That Will Ensure Defect-Free Repairs

A. Use approved materials and working techniques to repair damaged parts

(NOTE: Repair procedures are developed with the objective of equaling as nearly as possible the electrical and strength properties of the original part with a minimum increase in weight.)

B. Avoid abrupt changes in cross-sectional areas by tapering joints; abrupt changes may cause dangerous stress concentration

C. Make all small patches round, oval, or with rounded corners instead of square or rectangular

D. Avoid patches that project above the original surface; be sure the outside surface of high-speed aircraft is smooth to ensure proper performance

E. Uniformity in core thickness, facings, and density and cell size of core are extremely important

F. Punctured facings, delaminations, oil contamination, and fractured core in all areas must be repaired by removal of all damaged material and replacement with approved materials of the same thickness as the original

G. In all composite repairs, it is important to determine the direction of the warp in the original facings so the direction of the warp in the replacement layers can be made to match in each ply

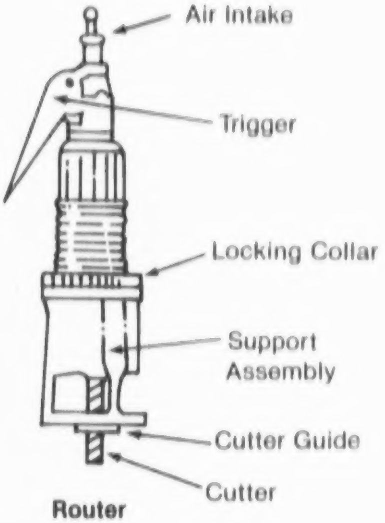
TECHNICAL INFORMATION SUPPLEMENT #10 — Tools and Equipment Used In Metal Bonded Honeycomb Repair and Their Correct Uses

A. Router — Pneumatically-powered, hand-operated tool used in conjunction with a support assembly, bit, and template to prepare damaged honeycomb for repair (See Figure 1)

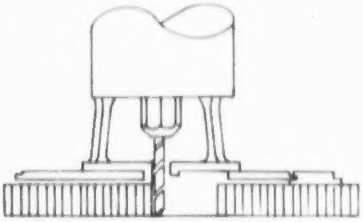
B. Router support assembly — Attachment which threads onto the router body with provisions for adjusting the desired depth of cut with a locking (clamping nut) mechanism (Figure 1)

EXAMPLE:

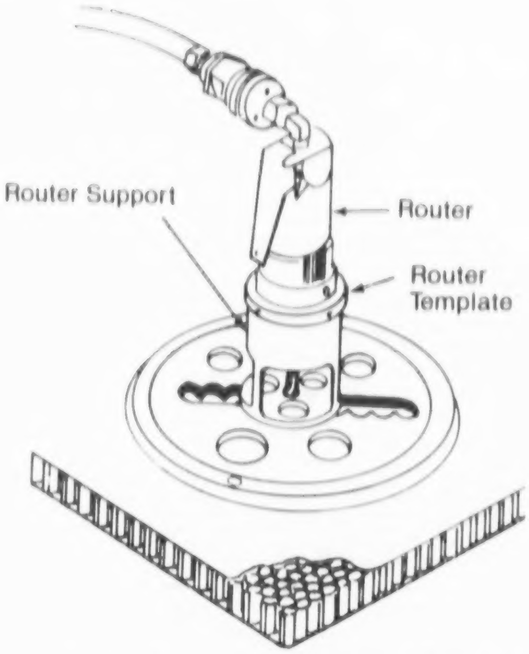
FIGURE 1


Air Intake
Trigger
Locking Collar
Support Assembly
Cutter Guide
Cutter

Router



Support Assembly


Router Support
Router
Router Template

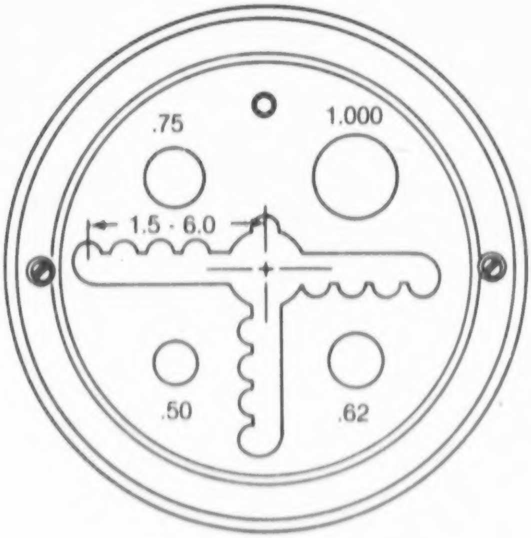
Router, Support Assembly, and Template

Source: EA-AC 65-15A.

C. Template — Guide used in conjunction with the router and support assembly to remove various sizes, shapes, and contours of damaged honeycomb areas (Figure 2)

EXAMPLE:

FIGURE 2

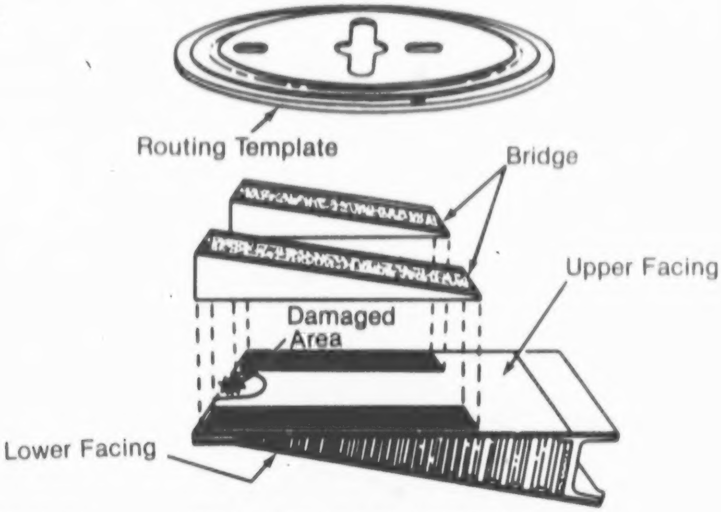

.75
1.000
1.5 - 6.0
.50
.62

Source: EA-AC 65-15A. Multi-Template

D. Wedge blocks — Wooden blocks at least six inches long with approximately the same degree of angle as the repair panel; used to support, align, and hold the template in proper position during the cutting operation (Figure 3)

EXAMPLE:

FIGURE 3


Routing Template
Bridge
Upper Facing
Damaged Area
Lower Facing

Source: EA-AC 65-15A. Wedge Blocks and Application

E. Pressure jigs — C-clamps, locally manufactured jigs, or vacuum fixtures used to apply pressure to repairs on underside surfaces of honeycomb panels to hold materials and resins in place until repair is cured

F. Scales — Device used to weigh adhesive ingredients in grams or parts to ensure accurate mixing

G. Infrared lamp — Heat bulb or bulbs used to shorten repair curing time

H. Explosive meter — Device used to detect and indicate the intensity of combustible gases in the repair area

I. Double-backed tape — Adhesive-like tape that is sticky on both sides, and both surfaces are used to hold down the template and bridges to allow use of the router

J. Manufacturer's maintenance or structural manual — Document which provides information pertaining to allowable repairs and techniques for aircraft

K. Heat gun — Source of electrically heated air used to cure sealants, adhesives, and repair compounds; has an approximate temperature range of 150°F to 500°F

L. Heating blankets — Thermostatically controlled heating blankets are similar to the household heating pad in that they are placed on an area to provide a source of heat

(NOTE: These come in different sizes, and they operate more economically and efficiently if they are blanketed with several layers of insulation.)

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TECHNICAL INFORMATION SUPPLEMENT #11 — Composite Assemblies

A. Boron composite assemblies

Boron is a new material being used on modern day aircraft. It is used on such structures as rudders, vertical and horizontal stabilizers, and longerons. Some of the aircraft using boron are the F-14, F-15, F-16, and the B-1.

At the present time, boron composites are used mostly for aircraft skins over honeycomb or conventional structures. Boron is used because of its high strength and light weight. Boron filaments are used as reinforcing materials coupled with an epoxy resin. The boron filament is made by the chemical vapor plating of tungsten filament (0.5 mils thick) with boron trichloride. The boron filaments are usually 4 mils thick, and after being impregnated with epoxy resin on a thin fiberglass cloth, they attain the thickness of 5 mils. The prepreg tape is manufactured in 4-inch-wide strips and is laid up by hand to the desired thickness.

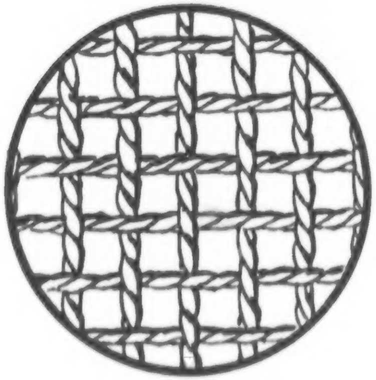
Boron composites are very costly because of the high cost of tungsten and the slow hand lay-up of skins and panels. Research and development of machines to do the lay-up work will greatly reduce the manufacturing cost in the near future.

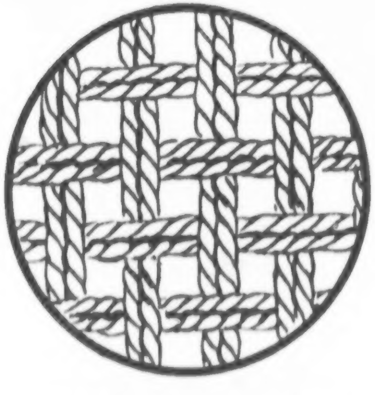
B. Graphite composite assemblies

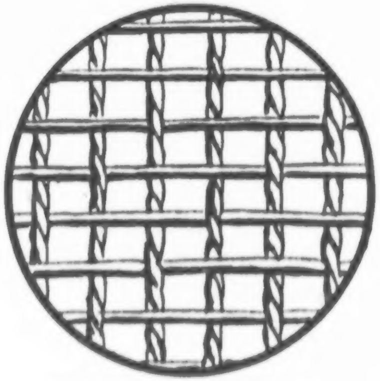
Graphite is lighter and less expensive than boron. It does not have the stiffness or strength of boron, but it can be formed into intricate shapes whereas boron cannot. Graphite composites are used on doors, fairings, ribs, speed brakes, and skins of modern aircraft.

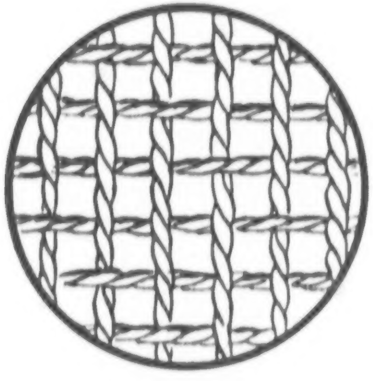
Graphite filaments are made by subjecting a strand of rayon to intense heat and pressure. The graphite strand is then laid up on a thin fiberglass cloth carrier and impregnated with epoxy resin. The prepreg tape is manufactured in 4-inch-wide strips and is laid up by hand like boron prepreg material. Each layer is laid up at different angles to produce strength and stiffness in all directions within the part.

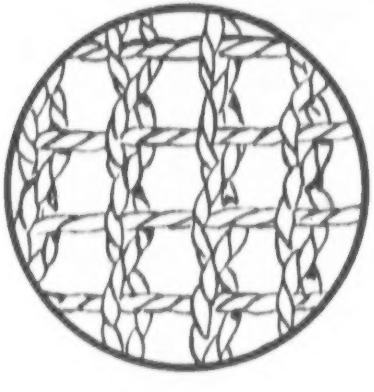
Weave Patterns for Fiberglass Cloth


Taffeta Weave


Basket Weave


Crowfoot Satin


Twill


Leno

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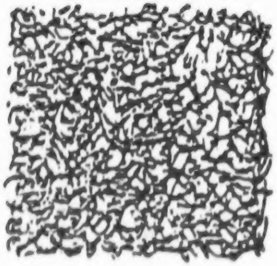
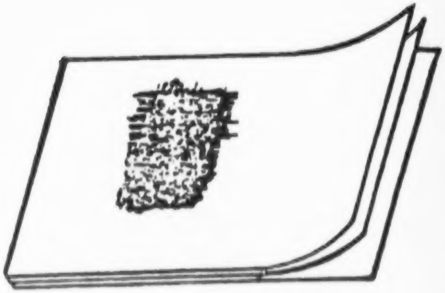
TM #1

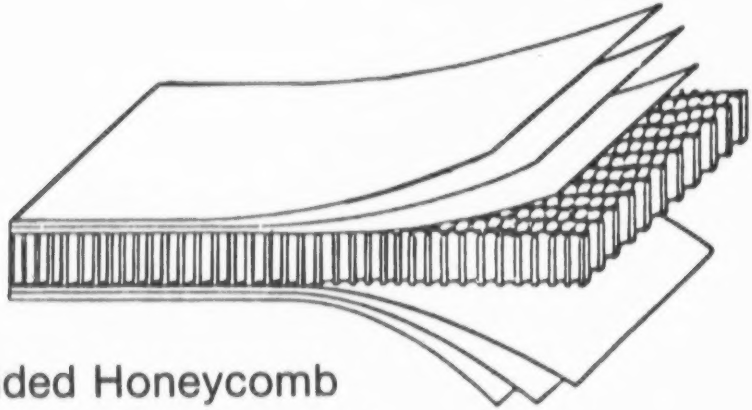
Types of Fiberglass Construction



Molded Mat

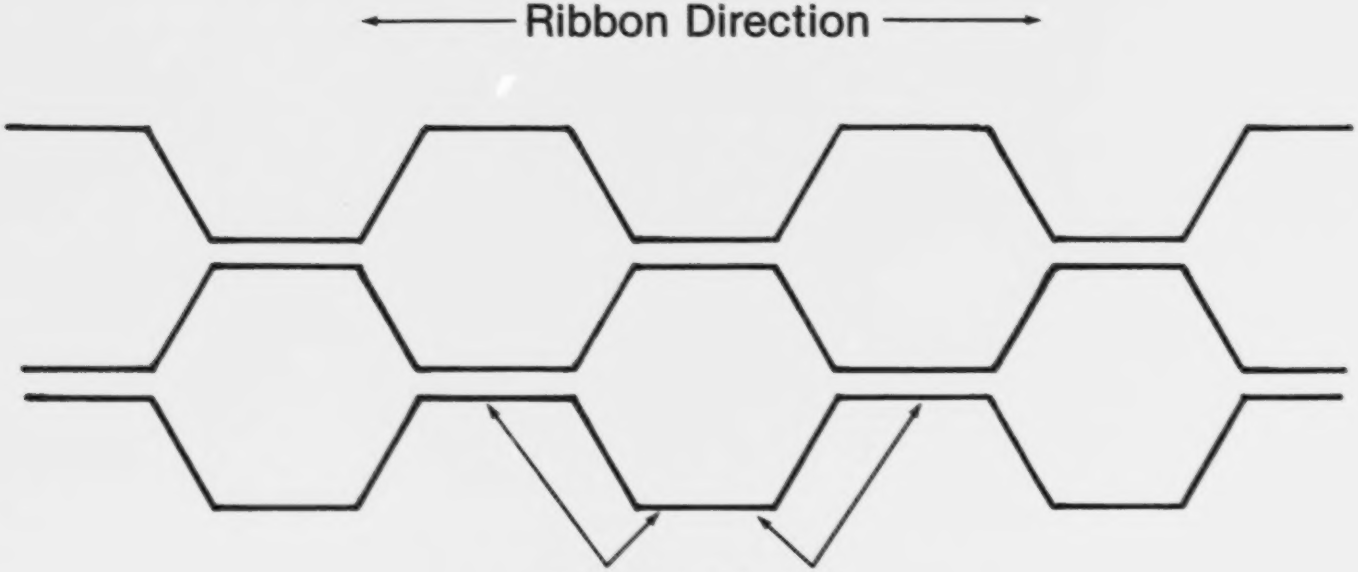


Laminated Fiberglass



Bonded Honeycomb
(Sandwich Construction)

Honeycomb Manufacturing Processes



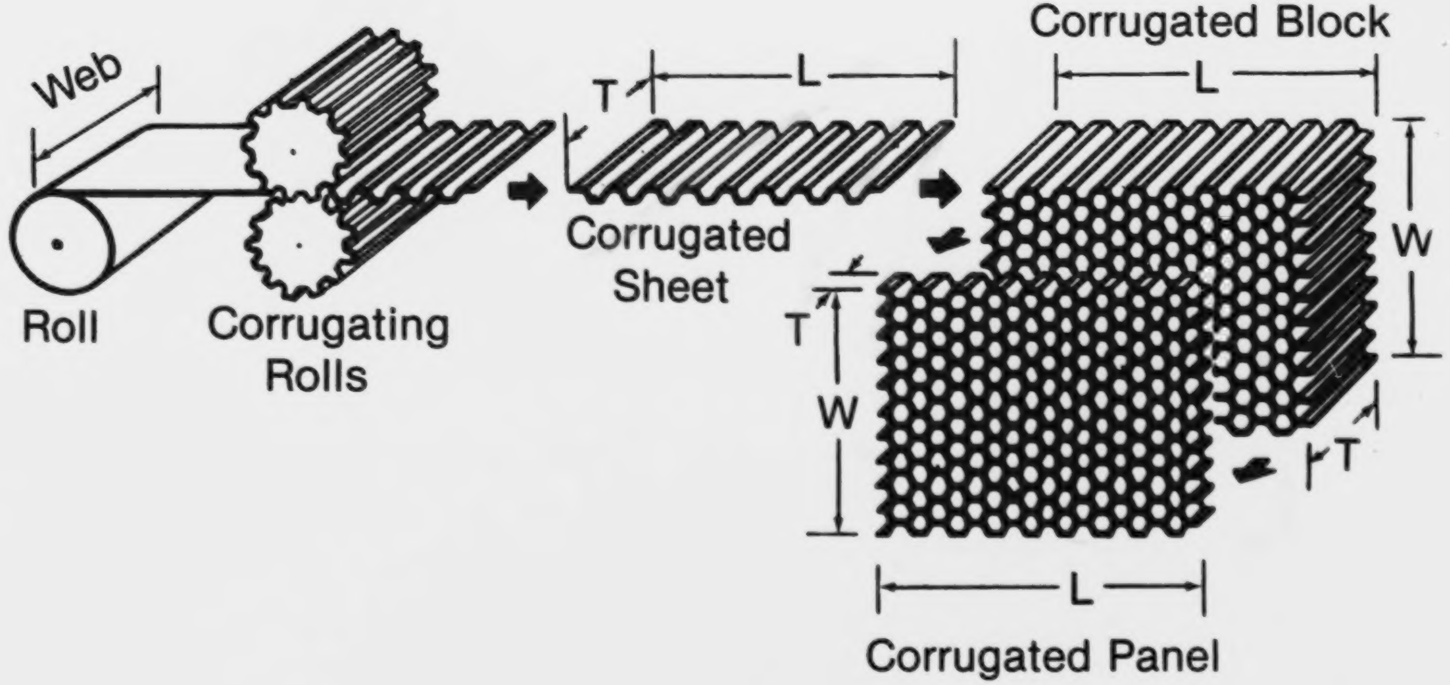
← Ribbon Direction →

Bonding Points

Ribbon

Honeycomb Manufacturing Processes

(Continued)


Web
Roll
Corrugating Rolls
T
L
Corrugated Sheet
Corrugated Block
L
W
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T
W
T
L
Corrugated Panel

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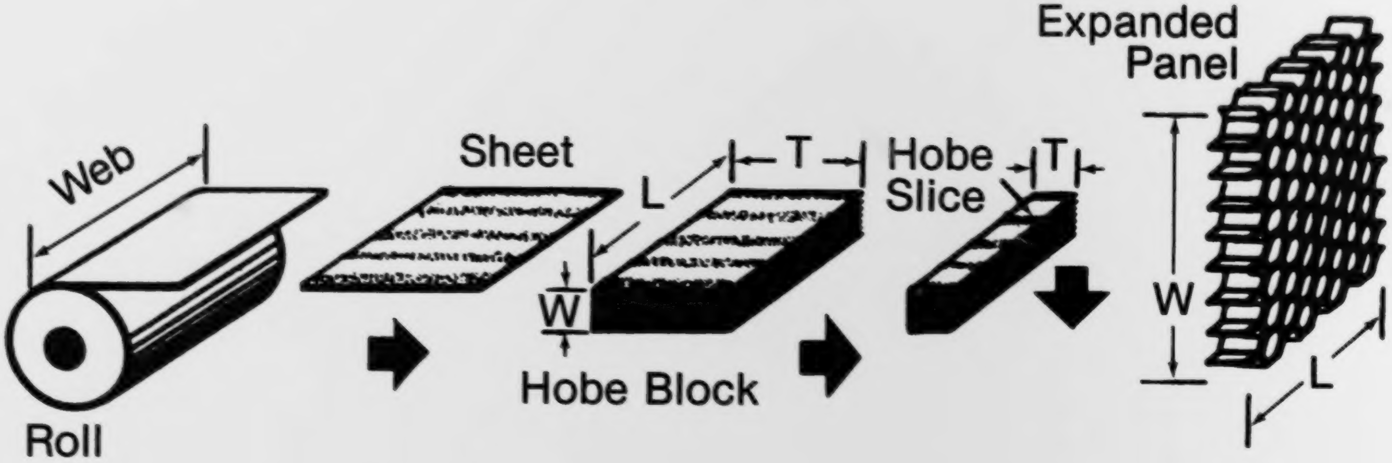
Honeycomb Manufacturing Processes

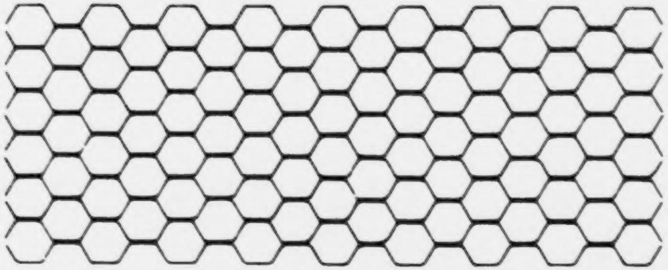
(Continued)


Web
Roll
Sheet
L
T
W
Hobe Block
Hobe
Slice
T
Expanded
Panel
W
L

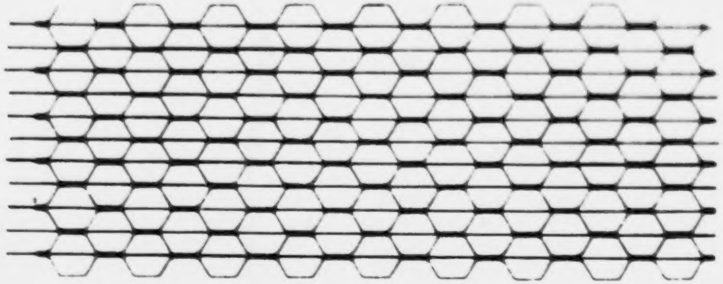
A201C-65

TM #5

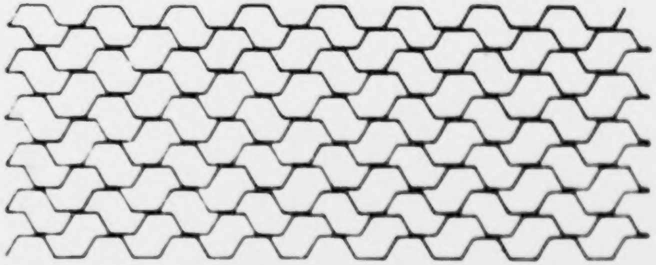
Honeycomb Core Cell Configuration



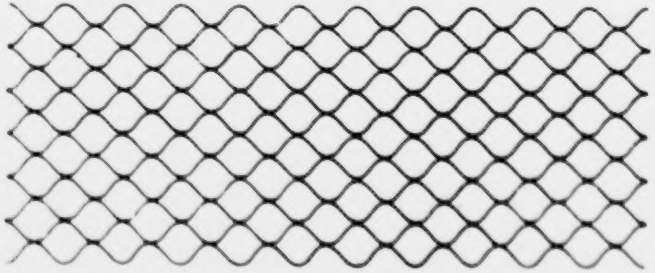
Hexagon



Reinforced Hexagon



Staggered Hexagon



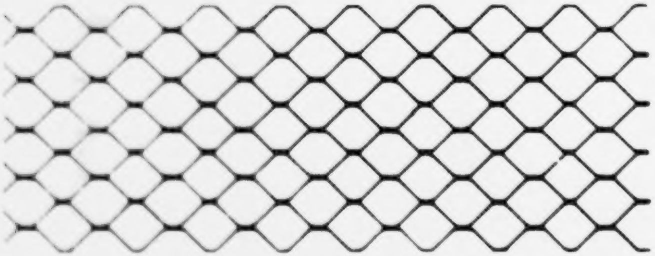
Sine Wave

A201C-67

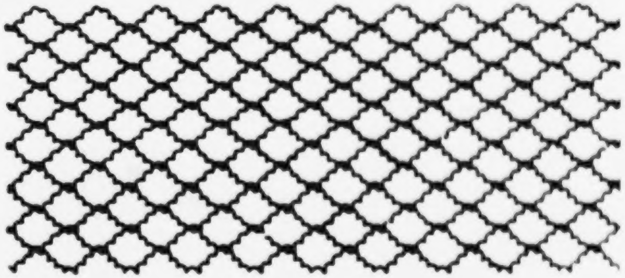
TM #6

Honeycomb Core Cell Configuration

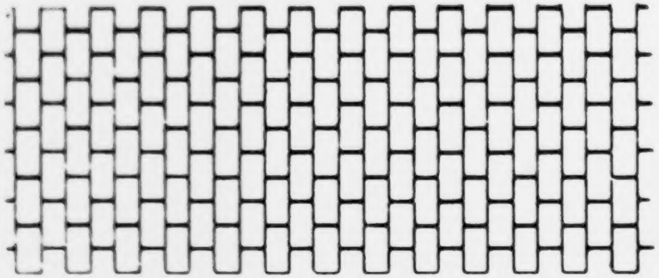
(Continued)



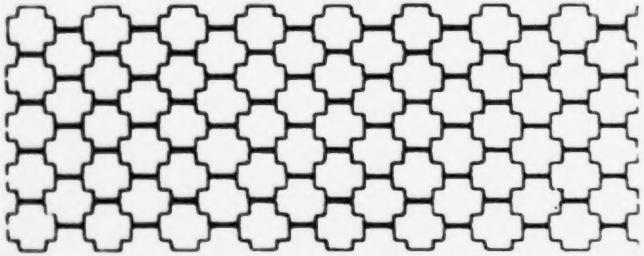
Square



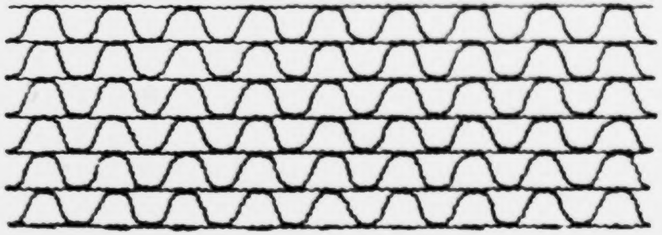
Corrugated Square



Rectangular

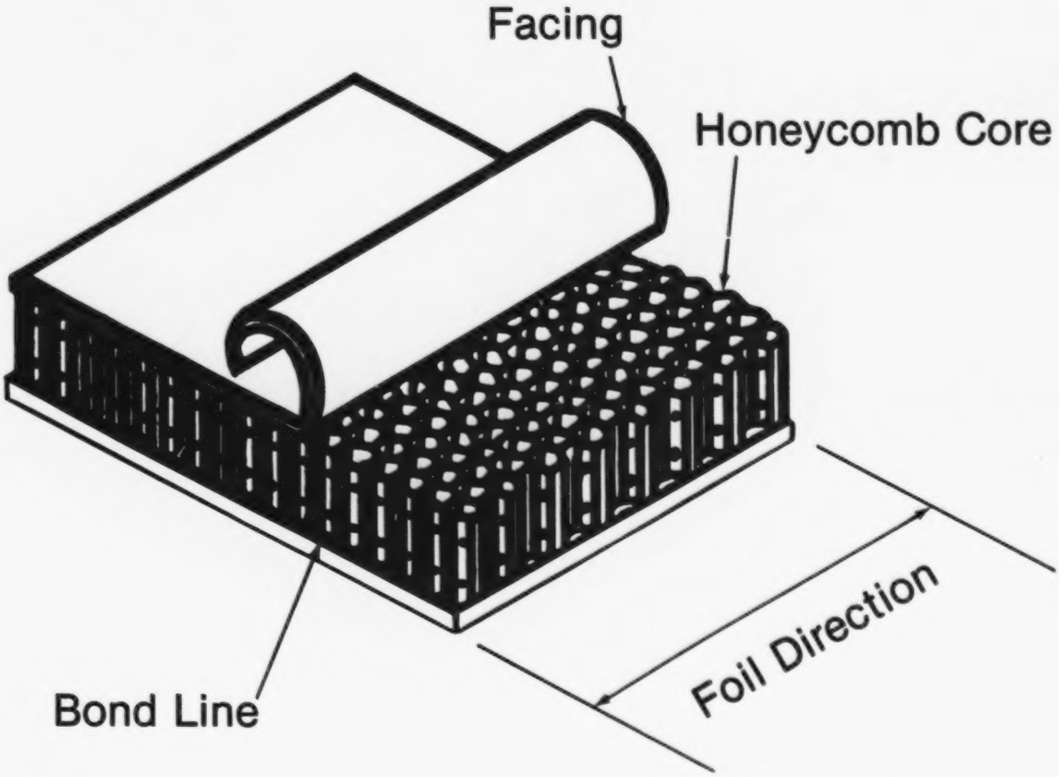


Cruciform



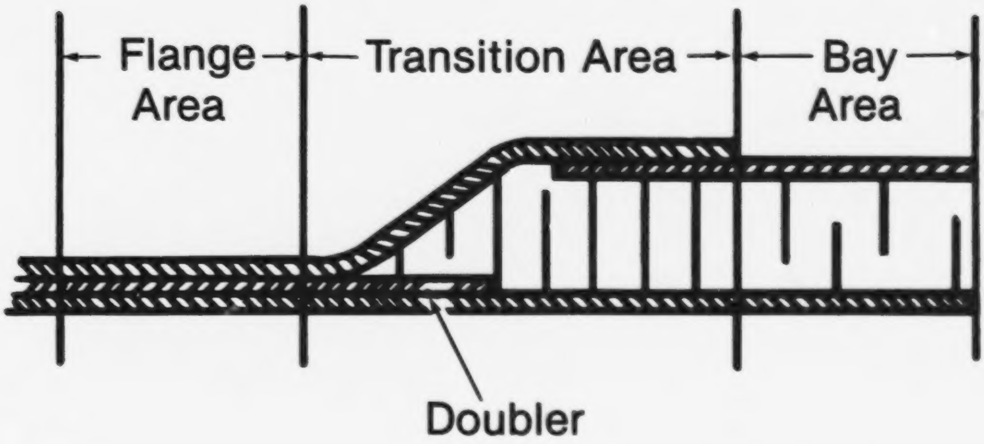
Multiwave or Double-Corrugated

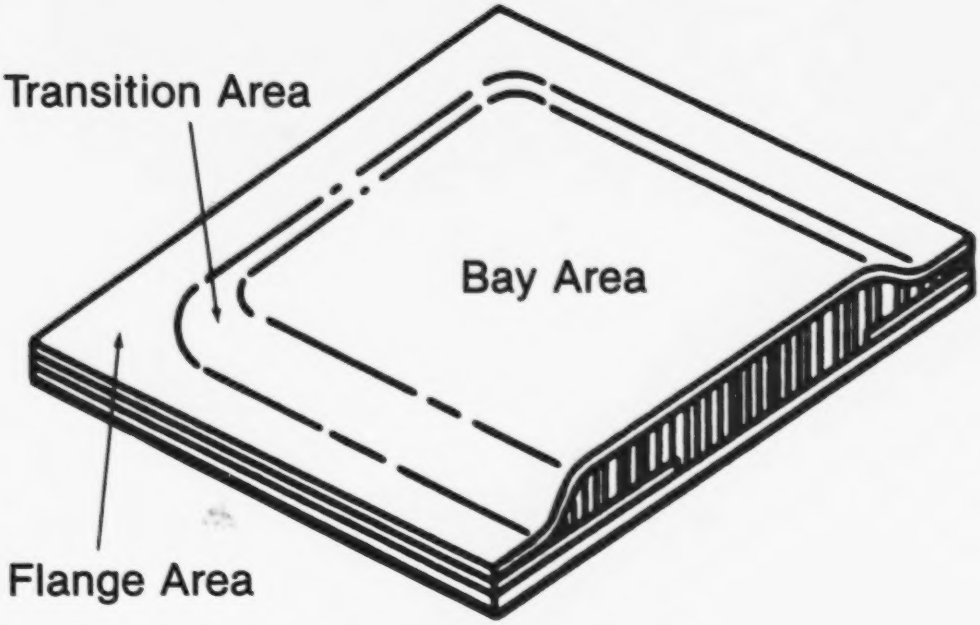
Honeycomb Structure


Facing
Honeycomb Core
Bond Line
Foil Direction

Source: EA-AC 65-15A.

Honeycomb Panel Sections


Flange Area
Transition Area
Bay Area
Doubler

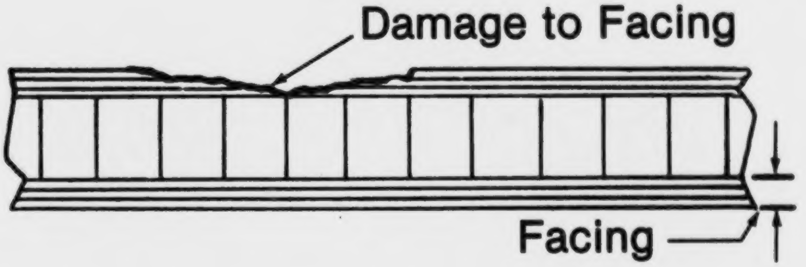

Transition Area
Bay Area
Flange Area

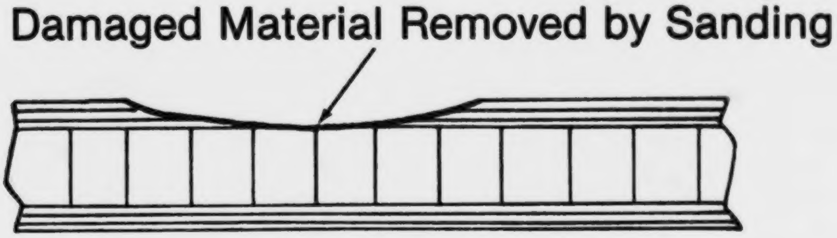
Crushed Edge Design

Source: EA-AC 65-15A.

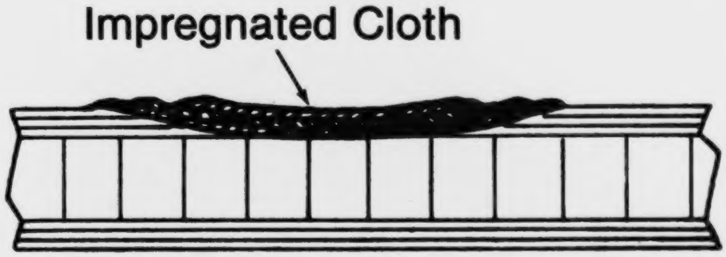
Scarf Method of Ply Removal and Insertion

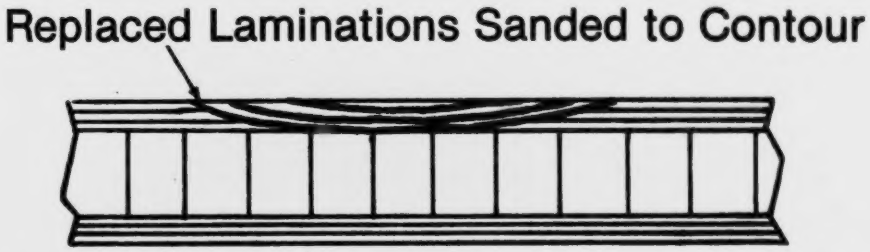
Removal


Damage to Facing
Facing


Damaged Material Removed by Sanding

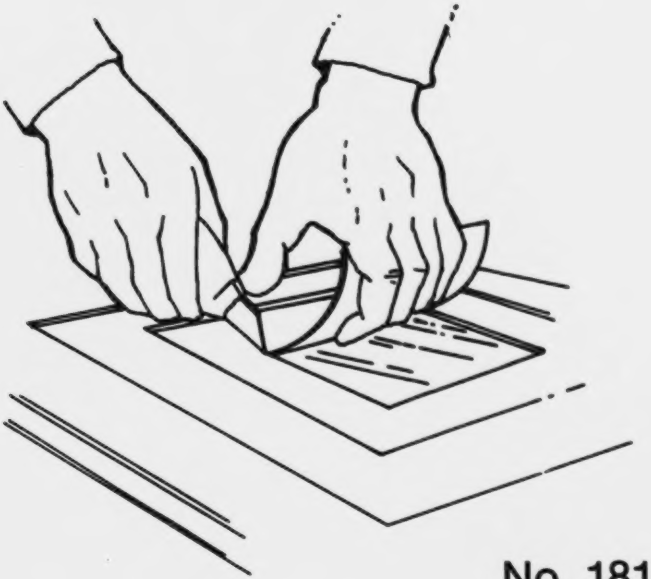
Insertion

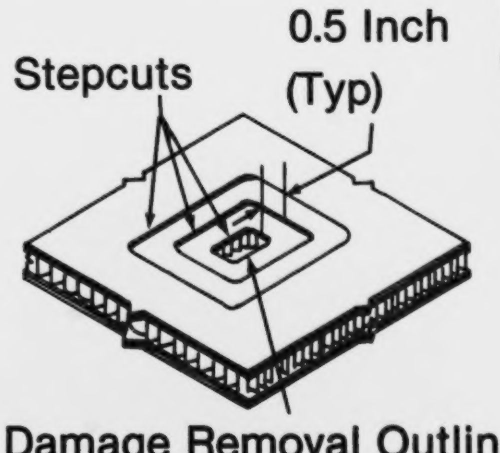

Impregnated Cloth


Replaced Laminations Sanded to Contour

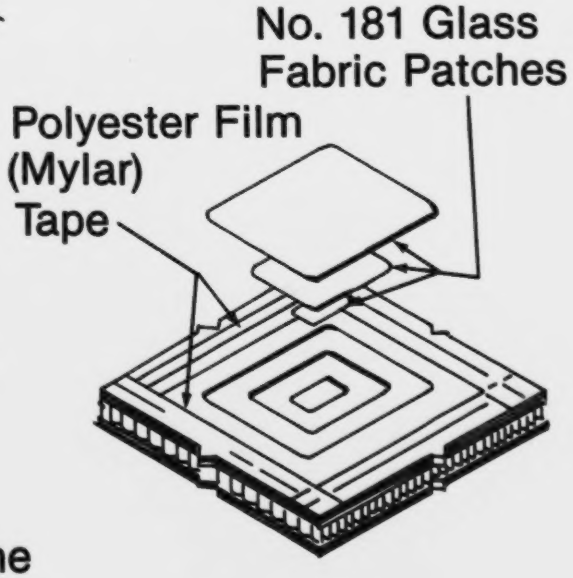
Removing Damaged Face Plies on Fiberglass Panel

(Step-Joint Method)



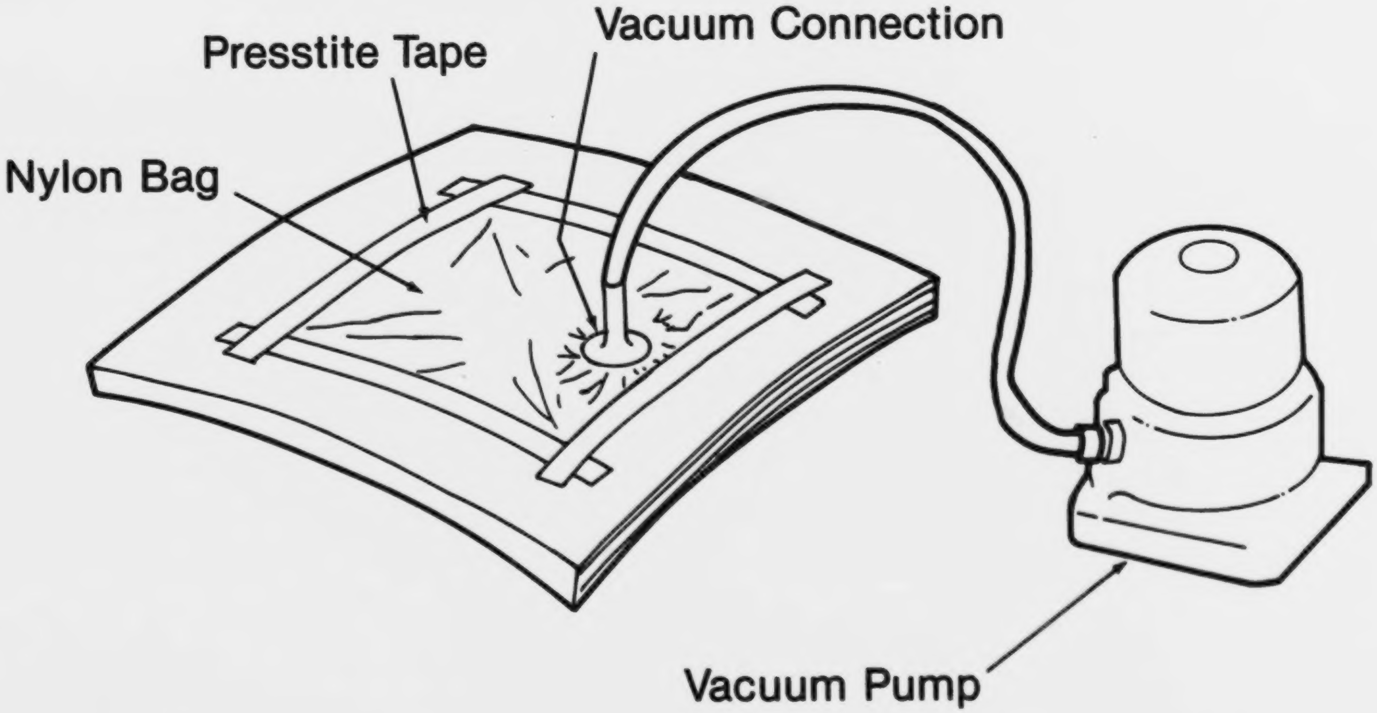

Stepcuts
0.5 Inch
(Typ)
Damage Removal Outline

Facing Preparation


No. 181 Glass
Fabric Patches
Polyester Film
(Mylar)
Tape

Ply Insertion

Vacuum Bag Pressure Curing


Vacuum Connection
Presstite Tape
Nylon Bag
Vacuum Pump

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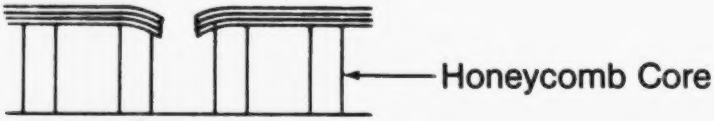
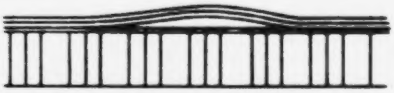
TM #12

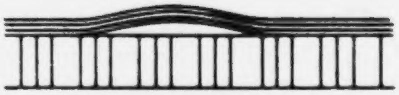
Panel Damage


Honeycomb Core

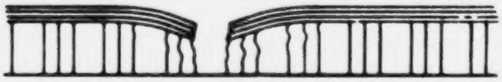
Perforation



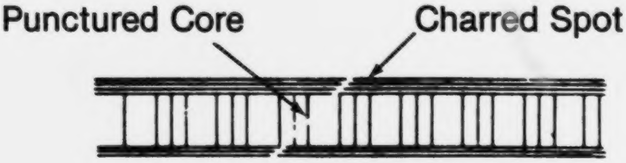
Delamination



Separation

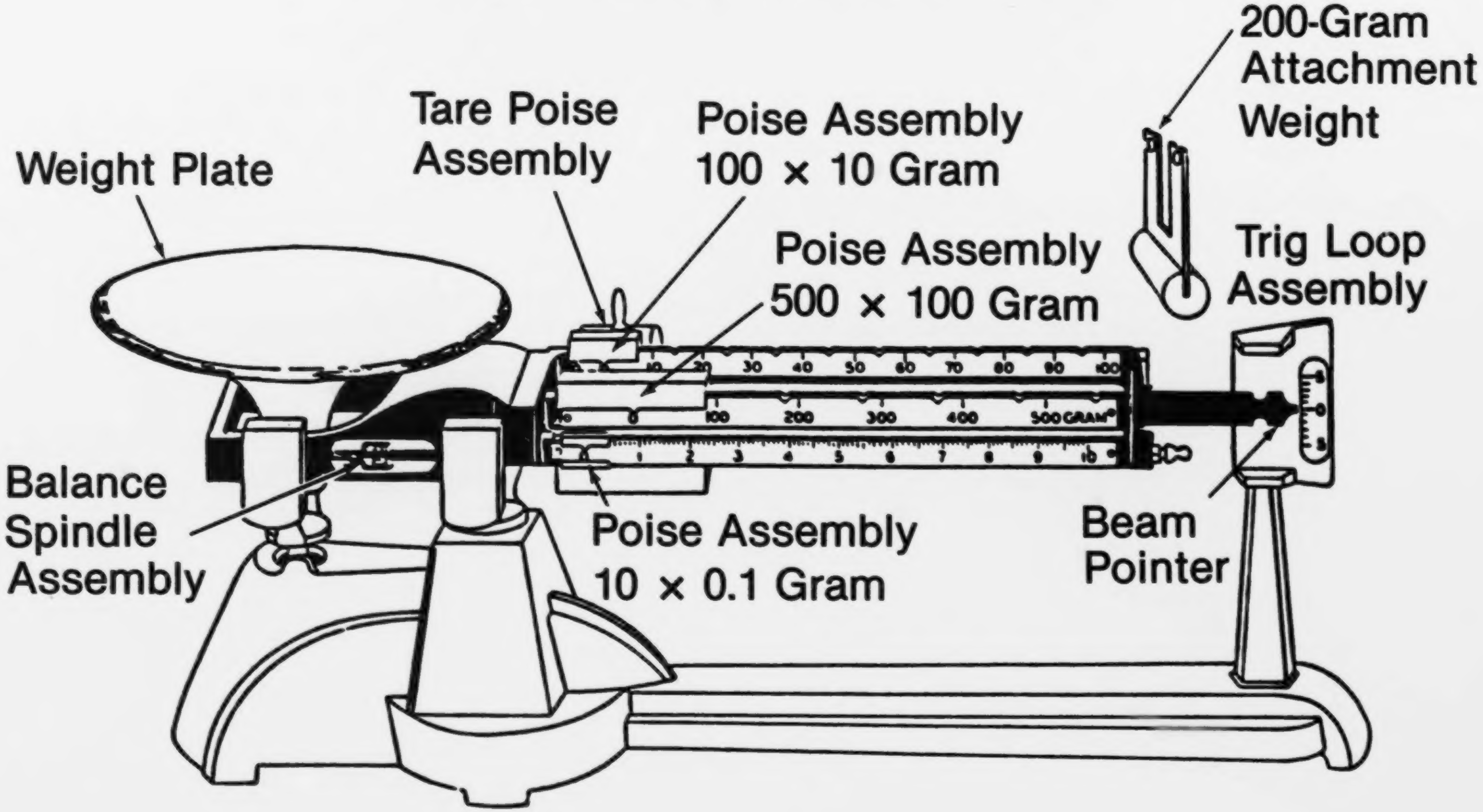


Core Damage


Punctured Core
Charred Spot

Lightning Strike

Triple-Beam Balance Scale


200-Gram Attachment Weight
Tare Poise Assembly
Poise Assembly 100 × 10 Gram
Weight Plate
Poise Assembly 500 × 100 Gram
Trig Loop Assembly
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500 GRAM
1
2
3
4
5
6
7
8
9
10
Balance Spindle Assembly
Poise Assembly 10 × 0.1 Gram
Beam Pointer

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TM #14

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A201-C

WORKBOOK SUPPLEMENT #1 — Discuss Usages and Characteristics of Materials Used in Repair of Bonded Structures

An aviation maintenance technician who has a thorough understanding of the characteristics and usages of materials used in bonded structures will be better equipped to select materials which will return the aircraft structure to its original strength and appearance.

PART I

Write the correct names of the materials used in repair of bonded structures in the blanks before their usages and characteristics.

A. ______________________________ Sometimes called a promoter

B. ______________________________ A water-soluble plastic material used as a parting agent

C. ______________________________ Any of the chemical compounds which suppress the inhibitor in a polyester resin

D. ______________________________ Has the texture and look of wool cloth

E. ______________________________ Short, loose fibers that are mixed directly into the resin

F. ______________________________ The strands have no pattern, and in its uncured stage looks quite porous

G. ______________________________ Parting agent used with epoxy resins only

H. ______________________________ Resins commonly used as adhesives

I. ______________________________ Used to control viscosity of a resin

J. ______________________________ Used to expose the surface of a bonded structure

K. ______________________________ Resin system used to stabilize the core of nylon honeycomb

L. ______________________________ Resin system used strictly for mat molded fiberglass parts and laminated glass cloth structures

WORKBOOK SUPPLEMENT #1

PART II

Answer the following questions relating to materials used in repair of bonded structures.

A. List two commonly used cleaners or paint removers approved for bonded structures.

1. ______________________________

2. ______________________________

B. Name four types of cloth commonly used in repair of fiberglass and metal bonded honeycomb assemblies.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

C. What is the purpose of a parting agent?

____

____

____

____

D. What is the usage for polyester resin?

____

____

____

E. What is the most common usage for glass fabrics in metal bonded honeycomb repairs?

____

WORKBOOK SUPPLEMENT #1

F. What type of material is used in the hole-filling technique used to repair metal bonded honeycomb?

G. What is the purpose of spraying primer on metal bonded honeycomb?

H. Where would a technician use an adhesive primer?

I. Where and why is Duxseal sealing compound used in repairing metal bonded honeycomb?

J. What is Corrogard, and how is it applied to metal bonded honeycomb?

K. What is type 38 adhesive, and where is it most commonly used?

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WORKBOOK SUPPLEMENT #2 — Describe the Types and Characteristics of Bonded Structures

An aviation maintenance technician must be able to evaluate bonded structure to determine airworthiness and must also be able to plan and perform any needed repairs. Knowledge of types of construction and all associated characteristics (strength, hardness, flexibility, electrical conductivity, weight, and many others) will enable the technician to effectively inspect, evaluate, plan, and repair a bonded structure to return it to its original strength and appearance.

Complete the following statements by writing the correct answers in the blanks.

A. Fiberglass assembly will stand up to the same high ________________ that glass will, but because it is made from fibers it ________________ ________________ break like glass.

B. A fiberglass assembly is much better to use than metal where ________________ ________________ transmission is needed.

C. The four types of bonded assemblies found in aircraft are

1. ____
2. ____
3. ____
4. ____

D. Composites are combinations of materials differing in ________________ or ________________ .

E. When replacing aluminum structure with graphite/epoxy composite structure, weight reductions of ________________ or better are common.

F. Metal bonded honeycomb is structure consisting of a combination of ________________ ________________ material, assembled and fixed in relation to each other so the ________________ of each can be used to attain specific structural advantages for the whole assembly.

WORKBOOK SUPPLEMENT #2

G. Metal bonded honeycomb has superior strength-to- ______________ ratio over convential structures.

H. Metal bonded honeycomb has relatively ______________ cost when compared to ______________ structure.

I. The materials used in special applications for metal bonded honeycomb structures are

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________

J. Metal bonded honeycomb structures are made by bonding a ______________ between ______________ face plies.

K. The three areas found on honeycomb panels are

1. ______________________
2. ______________________
3. ______________________

L. The area between the bay area and the edge of the panel is known as the ______________ area.

M. A ______________ is used to add strength to the flange area.

N. A metal bonded honeycomb assembly has ______________ facings. The most commonly used alloys are ______________ and ______________ .

O. The term honeycomb is used because the ______________ shape of the core resembles the hive in which bees store their honey.

WORKBOOK SUPPLEMENT #2

P. Core material is made by the ________________ process or by the ________________ process.

Q. One advantage of HOBE over the corrugated form of honeycomb core is that it may be ________________ and ________________ with little or no damage to the ________________.

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WORKBOOK SUPPLEMENT #3 — Analyze Statements Related to Fiberglass and Composite Bonded Structure Repair Procedures

Bonded fiberglass and composite structure repair procedures are developed with the objective of equaling as nearly as possible the strength and sometimes the electrical properties of the original part with a minimum increase in strength. These repairs can only be accomplished by a trained technician using approved materials and proper repair techniques.

PART I

Write a "T" for true or an "F" for false in the blanks before the following statements.

______A. Stress concentration can be eliminated when making scarf repairs in composite structures by using a core filler of higher density than the original material

______B. The most effective method for determining if the proper ratio of resin-to-catalyst was used when making epoxy repairs is to mix enough epoxy to have a sample for testing after curing

______C. Superficial scars, scratches, surface abrasion, or rain erosion on fiberglass laminates can generally be repaired by applying one or more coats of suitable resin (room temperature catalyzed) to the surface

______D. Fiberglass laminate damage not exceeding the first layer or ply can be repaired by sanding the damaged area until aerodynamic smoothness is obtained

______E. Fiberglass laminate damage that extends completely through one facing and into the core requires the replacement of the damaged core and facing

______F. Fiberglass damage that extends completely through a laminate sandwich structure may not be repaired

______G. When performing a tap test, a dull, flat sound defines no bond damage

______H. You must remove any surface coatings which hinder visual inspection when inspecting fiberglass bonded structure

______I. Any hammer or coin is suitable for the tap test

______J. Tap test suspected damaged area until damage borders are defined

WORKBOOK SUPPLEMENT #3

PART II

Read through the statements in Part I. In the following blanks write the letter of each false statement, and rewrite the statement to make it correct.

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WORKBOOK SUPPLEMENT #4 — Classify Bonded Honeycomb Structural Repairs

Damage must be evaluated and repairs must be classified so consistency in repair techniques can be maintained. How to repair damage to bonded structure will be determined by the classification of the repair and by the dimensions of the damage.

A. Supply the class of fiberglass bonded honeycomb repair when given the following related data. Write the correct answers in the blanks.

______________________ 1. Delamination to one ply only

______________________ 2. The outer ply is scratched during storage

______________________ 3. A hole which extends through both facings and the core

______________________ 4. A puncture which extends through two plies of the top facing and the core

______________________ 5. A crack in one facing only

______________________ 6. Erosion from rain or other weather conditions

B. Supply the class of metal bonded honeycomb damage when given the following related data. Write the correct answers in the blanks.

______________________ 1. A tear in the skin with no damage to the core

______________________ 2. A scratch that does not penetrate through the skin

______________________ 3. Delamination in which the core is not damaged

______________________ 4. Damage to both skins and the core

______________________ 5. A hole in the skin in which the core is damaged

______________________ 6. A dent in which the core is not damaged

______________________ 7. A hole in the outer skin in which the core is not damaged

______________________ 8. A nick which causes damage to the outer skin only

______________________ 9. Delamination in which the core is damaged

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WORKBOOK SUPPLEMENT #5 — Identify Types of Inspections Used to Evaluate Integrity of Metal Bonded Honeycomb Structures

An aviation maintenance technician must be aware of all inspection techniques which can be used to evaluate the integrity of a bonded structure. Some of these inspections will be performed by the maintenance technician and others will be performed by an NDI specialist. An aviation maintenance technician must use all available means to discover external and internal damage.

Given the specific damage data below, name the type of inspection to be used. Write your answers in the blanks.

A. Delaminated skin that has separated (oilcanned) from the core

____

B. Test a scratch to see if it is actually a scratch or if it is a crack

____

C. Delamination between the inner or outer skin and the core

____

D. Test the understructure of the wing for possible damage

____

E. Check for punctures or dents

____

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WORKBOOK SUPPLEMENT #6 — Discuss Repair Techniques Used on Bonded Structures

The aviation maintenance technician must be aware of some basic techniques involved in repairing bonded structures. These techniques will help to ensure that the repair returns the structure to its original strength while at the same time maintains the highest levels of serviceability.

Answer the following questions pertaining to repair methods that will ensure defect-free repairs.

A. If a technician creates a joint in a bonded structure and at the joint the cross-sectional area changes abruptly, what would be the result?

B. What type of materials and working techniques *must* be used to repair bonded structure?

C. What shapes of surface patches should be used?

D. What should be done to maintain the lowest aerodynamic drag factors when patching a high-speed aircraft?

E. When repairing bonded honeycomb, uniformity is extremely important in what areas?

WORKBOOK SUPPLEMENT #6

F. How is a punctured facing or fractured core repaired?

G. What should be given careful consideration when replacing facings in a fiberglass bonded honeycomb repair?

H. Once a repair has been assembled, what should be done?

I. What precaution should be taken to prevent corrosion inside a repaired metal bonded honeycomb structure?

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WORKBOOK SUPPLEMENT #7 — Discuss Proper Repair Procedures and Tools Used with Metal Bonded Honeycomb Structures

Aviation maintenance technicians must apply the rule, "Use the right tool for the right job," as much as possible. To do this they must be very familiar with their tools and equipment. If a repair is to be successful in maintaining strength and all the other characteristics of bonded structure, the proper repair procedures must be used.

Answer the following questions pertaining to tools, equipment, and repair procedures.

A. What tool is used to remove damage from metal bonded honeycomb?

____

B. How is the depth of the router cut controlled?

____

C. What is used to control the shape of the cut made by the router?

____

D. What kind of device is used to detect explosive atmospheres in the work area?

____

E. Where can damage evaluation charts and other information pertaining to allowable repairs and techniques be found for any specific aircraft?

____

F. What are the two most common ways of supplying heat to cure a repair?

1. ____
2. ____

G. Damage less than one inch in diameter is generally considered to be small core and facing damage. What type of repair is specified on pages 77-78 of the AC 43.13-1A&2A for use on a damaged area of metal bonded honeycomb that is considered to be small core damage?

____

WORKBOOK SUPPLEMENT #7

H. If balsa wood is used for the replacement core in a repair to a honeycomb structure, what must be kept in mind when cutting the core?

I. Why are microballoons used in the repairs which are made to laminated honeycomb panels?

J. What is the taper of the doubler used to repair a puncture to the facing of metal bonded honeycomb?

K. When is a potted compound repair used on metal bonded honeycomb?

L. What type of material is most commonly used to replace the aluminum core of metal bonded honeycomb?

M. A circular-shape repair in a transition area of a metal bonded honeycomb should not exceed what size in diameter?

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WORKBOOK SUPPLEMENT #8 — Discuss Characteristics of Boron and Graphite Materials

Many new materials are being used in bonded structures, thus creating airframe structures that are lighter and stronger. As an aviation maintenance technician, you must stay current on new materials, where they are used, and any changes the new materials cause in established repair procedures.

Test your knowledge of the materials boron and graphite by answering the following questions.

A. Where is the majority of boron composites being used in aircraft structure?

B. With what type of resin are the boron filaments used as reinforcing material?

C. How are boron filaments created?

D. How is boron material made available for use?

E. How does graphite compare to boron?

F. How are graphite filaments created?

G. How is the graphite material made available for use?

____

H. 1. How are graphite composites laid up?

____

____

2. Why?

____

____

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ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #1

PART I

A. Accelerator
B. Polyvinyl alcohol (PVA film)
C. Catalyst
D. Woven glass cloth
E. Chopped fibers
F. Mat binder
G. Polyethylene (PE) film
H. Epoxy resin system
I. Thixotropic agent
J. Paint removers and cleaners
K. Phenolic resin system
L. Polyester resin system

PART II

A. 1. MEK
   2. Acetone

B. 1. Scrim cloth — like cheesecloth
   2. #128 Volan "A" finish
   3. #181 Volan "A" finish
   4. #191 Volan "A" finish

C. To end up with a smooth surface, pressure must be applied to a bonded structure repair; a parting agent prevents the devices used to create pressure from bonding to the repair

D. Used strictly for mat molded fiberglass parts and laminated glass cloth structures including fiberglass honeycomb enclosures

E. Overlay

F. Potting compound

G. To protect against erosion and corrosion

H. On a surface to be bonded

I. Used around a hole to be repaired in a bonded honeycomb structure; acts as a reservoir to ensure adequate filling with potting compound

J. An aluminum pigmented erosion and corrosion preventive which can be either sprayed or brushed on bonded honeycomb repairs

K. Epoxy resin system used with fiberglass cloth when fabricating overlay repair to metal bonded honeycomb

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #2

A. Temperature; does not

B. Electrical wave

C.
1. Preformed
2. Mat molded
3. Solid laminate
4. Sandwich construction

D. Composition; form

E. 20 percent

F. Alternating dissimilar; properties

G. Weight

H. Low; conventional

I.
1. Stainless steel
2. Titanium
3. Magnesium
4. Plywood
5. Resin impregnated paper
6. Glass
7. Nylon
8. Cotton

J. Core; two

K.
1. Bay
2. Transition
3. Flange

L. Transition

M. Doubler

N. Two; 2024-T3; 7075-T6

O. Hexagonal

P. Corrugation; expansion

Q. Shipped; handled; cells

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #3

PART I

A. F
B. T
C. T
D. F
E. T
F. F
G. F
H. T
I. F
J. T

PART II

A. Stress concentrations can be eliminated when making scarf repairs in composite structures by avoiding abrupt changes in cross-sectional areas

D. Fiberglass laminate damage not exceeding the first layer or ply can be repaired by filling with a putty consisting of a compatible resin and clean, short glass fibers

F. Fiberglass damage that extends completely through a laminate sandwich structure may be repaired

G. When performing a tap test, a dull, flat sound defines a void or bond damage

I. A heavy coin is suitable for the tap test

Workbook Supplement #4

A. 1. Class II
2. Class I
3. Class III
4. Class II
5. Class II
6. Class I

B. 1. Class II
2. Class I
3. Class II
4. Class IV
5. Class III
6. Class I
7. Class II
8. Class I
9. Class III

Workbook Supplement #5

A. Visual or thumb-pressure test, tap test or metallic ring test

B. Caustic soda solution test

C. Tap test or metallic ring test; visual and thumb-pressure test can also be used to check outer skin

D. Boroscope inspection

E. Visual inspection

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #6

A. This abrupt change would cause a stress concentration with eventual failure of the joint

B. Approved materials and working techniques

C. Round, oval, or have rounded corners

D. Avoid patches that project above the original surface

E. Core thickness, facings, and density and cell size of core

F. Puncture facings, delaminations, oil contamination, and fractured cores in all areas must be repaired by removal of all damaged material and replacement with approved materials of the same thickness as the original

G. In all composite repairs, it is important to determine the direction of the warp in the original facings so the direction of the warp in the replacement layers can be made to match in each ply

H. Sufficient heat and pressure should be applied

I. Prime the repair with a corrosion inhibitor and seal from the atmosphere with finishing material

Workbook Supplement #7

A. Pneumatically-powered router

B. Provisions on the router support assembly

C. Template

D. Explosive meter

E. Manufacturer's maintenance or structural manual

F. 1. Heat guns
   2. Heating blankets

G. Overlap-type metal facing patch

H. Cut the core so that the grain will be perpendicular to the skin

I. To lower the density and increase the flexibility of the repair

J. 100 times the thickness of the metal

K. When the damage is less than one inch in diameter

L. Fiberglass honeycomb

M. Two inches

ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #8

A. Rudders, vertical and horizontal stabilizers, and longerons

B. Epoxy

C. Chemical vapor plating of tungsten filament with boron trichloride

D. Prepreg tape

E. Lighter base, less expensive, does not have as much strength or stiffness, and can be formed into intricate shapes whereas boron cannot

F. By subjecting a strand of rayon to intense heat and pressure

G. Prepreg tape

H. 1. Each layer is laid up at different angles
   2. To produce strength and stiffness in all directions within the part

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PROJECT GUIDE #1 — Repair Surface Scratches in Fiberglass Laminate

PURPOSE: To allow you to develop skill in repairing surface scratches that do not extend through the surface ply of a fiberglass laminate.

REFERENCE MANUALS: EA-ITP-AB

EQUIPMENT AND TOOLS:

A. Plastic squeegee or roller

B. Heating unit or heat lamps (250 to 300 watts)

C. Pyrex mixing cups

D. Fireproof can for MEK

E. Protective clothing

F. Canister-type respirator (approved for dry sanding)

G. Safety glasses or chemical face shield

H. Neoprene gloves

SUPPLIES AND MATERIALS:

A. Clean shop rags

B. Cheesecloth

C. MEK (methyl ethyl ketone)

D. 280-grit wet or dry sandpaper (silicon carbide)

E. Mylar or PE film

F. Polyester resin

G. Catalyst

H. Masking tape

I. Section of a fiberglass laminate structure

J. Scrap plastic or thin sheet metal

PROCEDURE:

WARNING

The potential of a fire hazard generally exists in the area where bonded honeycomb repairs are performed because of the low flash point of the repair materials, such as cleaning solvents, primers, and resins. Therefore, it is necessary that all fire precautions be observed closely. Certain fire safety prevention equipment, such as fireproof cans for solvents, flammable-waste cans, and vaporproof and explosion-proof lights, should be used.

With the potential of fire hazards in a honeycomb repair area, it is necessary to make sure that a suitable fire extinguisher is on hand or is located nearby and is ready for use. The extinguishing agents for all the materials used in bonded honeycomb repairs are dry chemicals or carbon dioxide; thus the standard CO_2 fire extinguishers should be on hand for use in areas where bonded honeycomb structures will be repaired.

Wear appropriate protective clothing and devices while dry sanding fiberglass.

A. Use clean cheesecloth moistened with MEK or other approved cleaning agent to carefully clean damaged area thoroughly, and immediately remove residue with dry cheesecloth (Figure 4)

WARNING

When using MEK or solvents of this type, avoid breathing vapors. Use mechanical ventilation or respiratory protection when working in a confined space or area. Avoid contact with skin, eyes, and clothing. Wear approved gloves, protective clothing, and eye protection. Keep away from sources of heat, fire, or sparks. Breathing vapors or allowing solvent to contact skin or eyes is hazardous. Heat, fire, or sparks can cause an explosion.

FIGURE 4

B. Lightly sand damaged surface with 280-grit sandpaper (Figure 5)

WARNING
Wear a respirator while sanding.

(NOTE: Wet sanding helps prevent fiberglass dust from becoming airborne.)

FIGURE 5

C. Clean sanded surface thoroughly using MEK (Figure 6)

(NOTE: Make sure that moisture and solvents are completely removed to prevent inhibiting the cure of the resin.)

FIGURE 6

D. Mix appropriate resin and catalyst in Pyrex mixing cups according to manufacturer's recommendation (Figure 7)

FIGURE 7

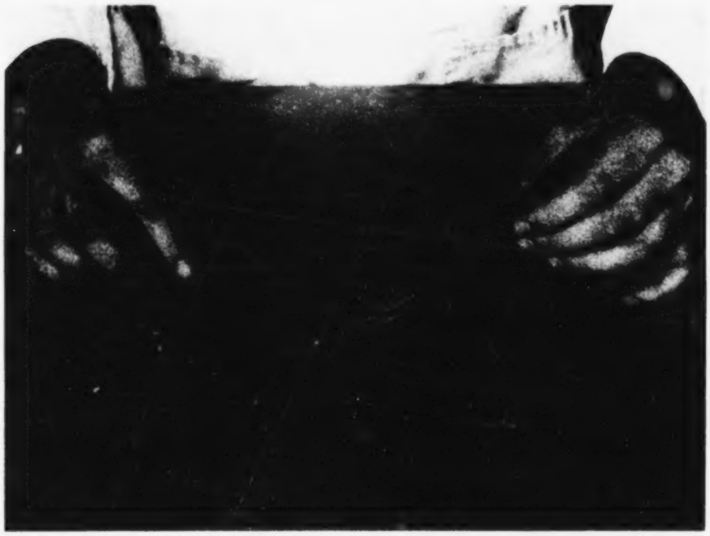
E. Apply one to two coats (depending upon severity of abrasion) of catalyzed resin to abraded surface using small piece of scrap plastic or thin sheet metal for applicator (Figure 8)

FIGURE 8

F. Over coated surface, apply a sheet of Mylar or PE film extending two or three inches beyond abraded area (Figure 9)

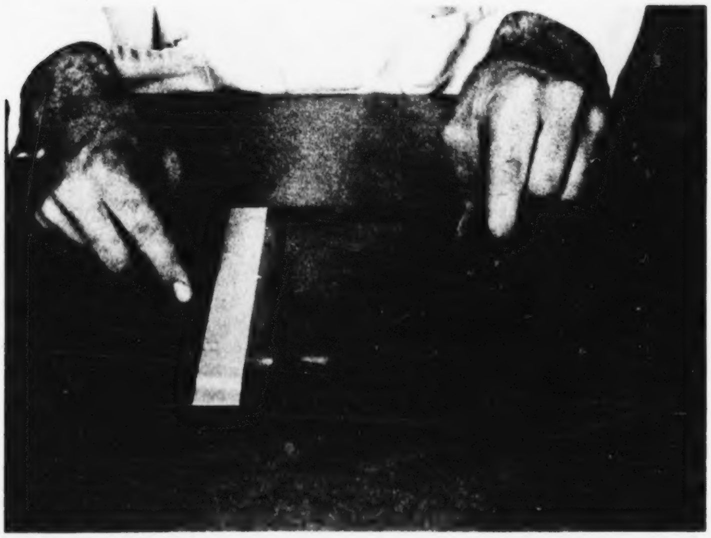
(NOTE: The Mylar or PE film prevents exposure to the air and will provide a smooth surface against which the resin may cure.)

FIGURE 9



G. Tape Mylar or PE film in place, and work out all air bubbles and excess resin with plastic squeegee or roller (Figure 10)

FIGURE 10



H. Cure resin coated surfaces at temperatures as specified by resin manufacturer's instruction sheet (Figure 11)

(NOTE: The curing time can be decreased by curing using heat lamps or a heating unit at temperatures specified on resin manufacturer's instruction sheet.)

WARNING

Review all manufacturer's safety instructions pertaining to curing at temperatures other than room temperature. Remember that an explosive atmosphere can exist in bonded structure repair areas.

FIGURE 11

I. After resin has cured or set, remove Mylar or PE film from surface of repair (Figure 12)

FIGURE 12

J. Remove excess resin by sanding

> **WARNING**
>
> **Wear a respirator while sanding.**

(NOTE: Wet sanding helps prevent fiberglass dust from becoming airborne.)

K. Clean work area, and return tools and equipment to proper storage area

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PROJECT GUIDE #2 — Remove Damage from Metal Bonded Honeycomb with a Router

PURPOSE: To allow you to develop skill in using an air-driven router to remove damage from metal bonded honeycomb structures.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

EQUIPMENT AND TOOLS:

A. Router (10,000 to 20,000 rpm)

B. Router support assembly

C. Metal-cutting, ¼-inch mill-end router bit or rotary file bit

D. Assorted templates or multi-template

E. Protective clothing

F. Safety glasses and face shield

G. Ear muffs or ear plugs

H. 6-inch rule

I. Approved canister-type respirator (required if honeycomb core to be routed is Nomex or fiberglass)

J. Large C-clamps

SUPPLIES AND MATERIALS:

A. Double-backed tape

B. Light oil lubricant (for use in router)

C. Metal bonded honeycomb, 12" × 12"

PROCEDURE:

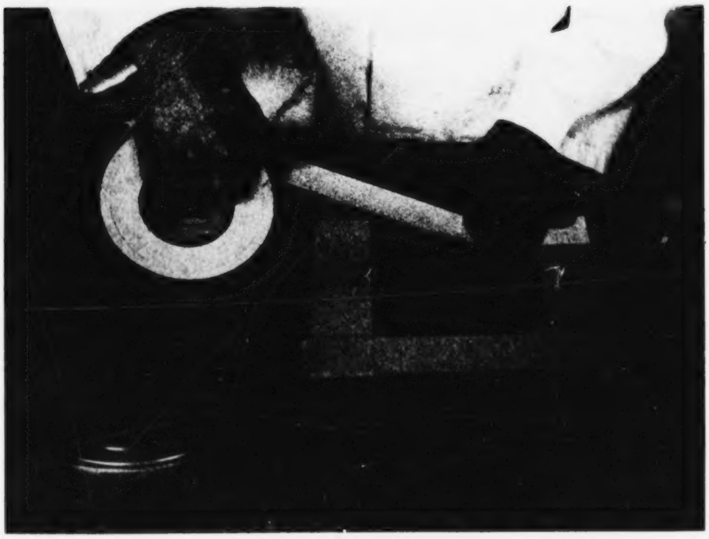
A. Inspect honeycomb material using appropriate methods to determine extent of damage at location #1, and use 6-inch rule to determine size of hole to be cut

B. Select template with opening matching area of damage to be removed (Figure 13)

FIGURE 13

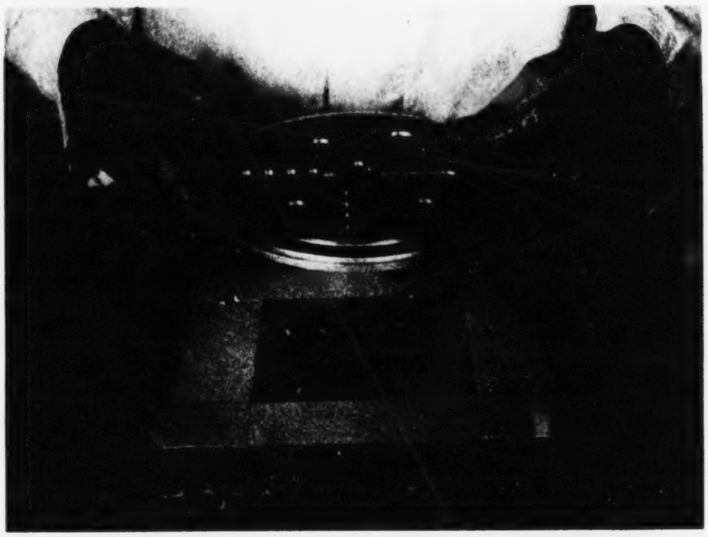
C. Apply double-backed tape around damaged area (Figure 14)

FIGURE 14



D. Center desired cutout guide hole in template directly over damaged area (Figure 15)

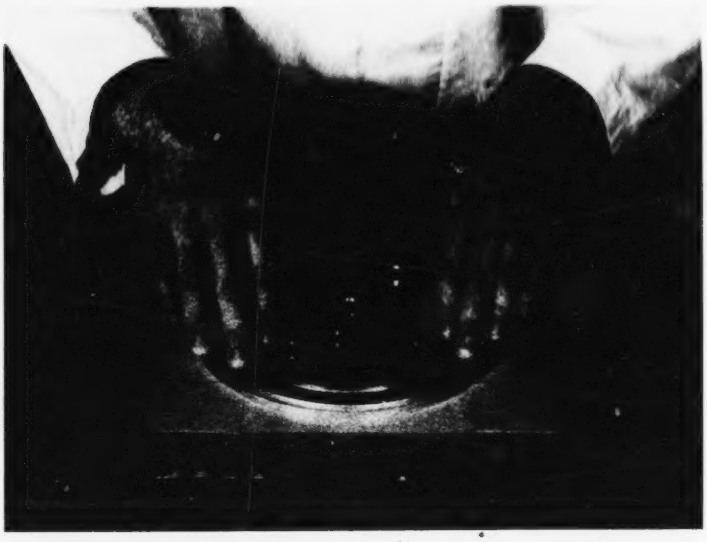
FIGURE 15



E. Press template down firmly over double-backed tape, making sure that it is secured in place (Figure 16)

(NOTE: This will avoid any creeping or misalignment of the template during the routing operation.)

FIGURE 16



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F. Set up and adjust router, router support assembly, and mill-end router or rotary file bit for removal of damaged area

1. Check router

   a. Place one or two drops of oil in air intake (Figure 17)

FIGURE 17

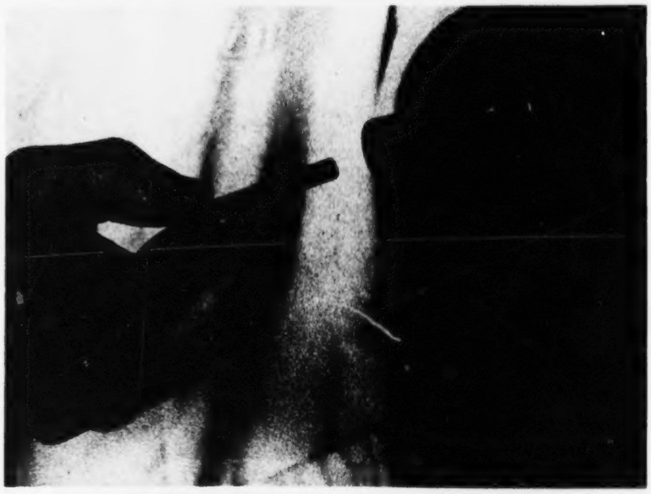
   b. Check router for freedom of rotation

2. Install mill-end router or rotary file bit

   a. Select a ¼-inch (right-hand spiral) bit of length required for depth of damaged area to be removed

   b. Insert shank of bit into collet end of router (Figure 18)

FIGURE 18

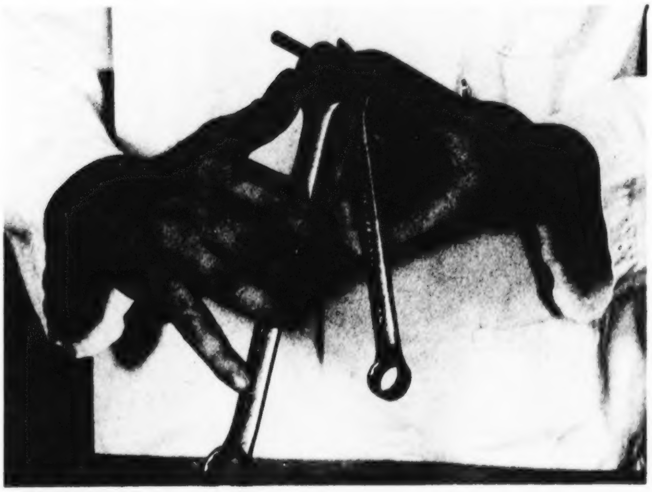


c. Tighten chuck snugly with appropriate open-end wrenches provided with router (Figure 19)

WARNING

Be sure that the collet is chucked properly into the router and that the mill-end bit is secure.

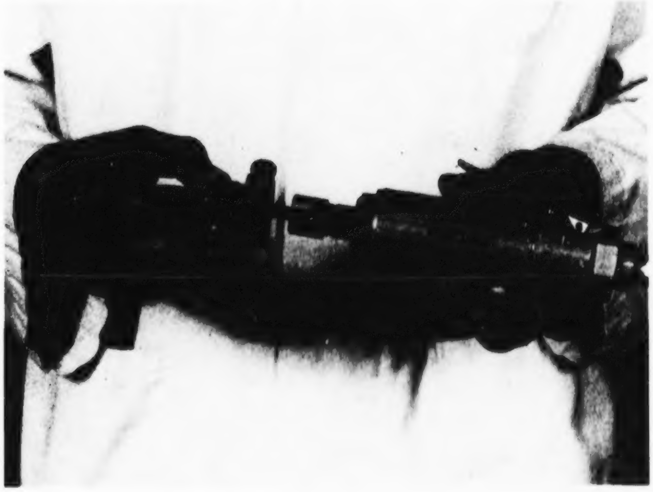
FIGURE 19



3. Install support assembly on router

   a. Place threaded sleeve of router support assembly around router collet (Figure 20)

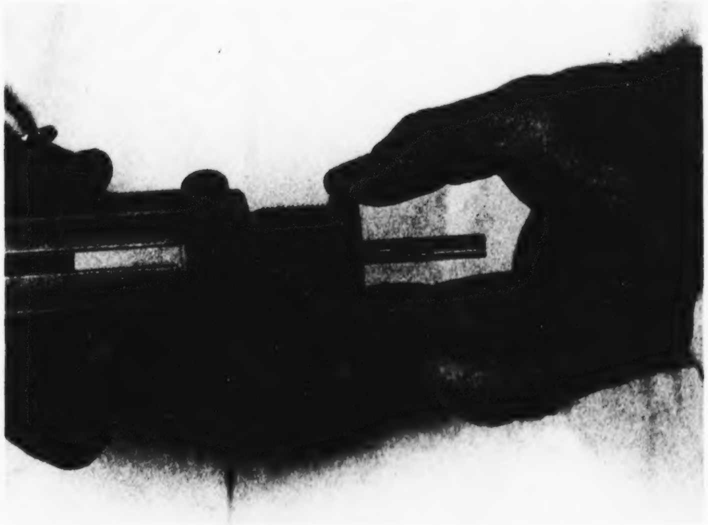
FIGURE 20



b. Install locknut on threaded sleeve by turning locknut until threads mesh (Figure 21)

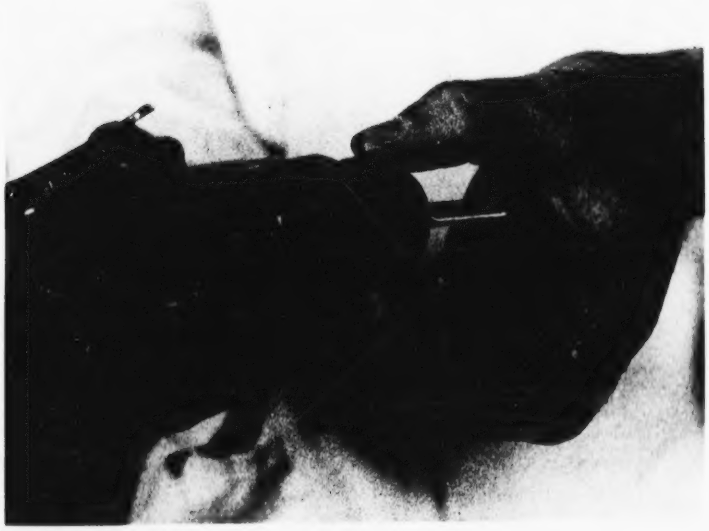
(NOTE: This must be done to carefully prevent the threads from being stripped.)

FIGURE 21



c. Turn lock nut clockwise until it is threaded on threaded sleeve (Figure 22)

FIGURE 22



4. Install router support on threaded sleeve of router support assembly (Figure 23)

FIGURE 23

5. Adjust for depth of cut
   a. Loosen support assembly lock nut
   b. Adjust router support assembly on threaded sleeve of router to desired depth of cut
   c. Turn lock nut until it is snug against router support assembly
6. Attach router air-intake plug in air-supply socket, and adjust air pressure to 90 pounds

G. Put on required personal protective clothing and devices including safety glasses and face shield

H. Secure metal bonded honeycomb section to workbench with large C-clamps (See Figure 24)

CAUTION

It may be necessary to place small squares of 1/4-inch plywood between the jaws of the C-clamps and the honeycomb material to prevent damaging the honeycomb material.

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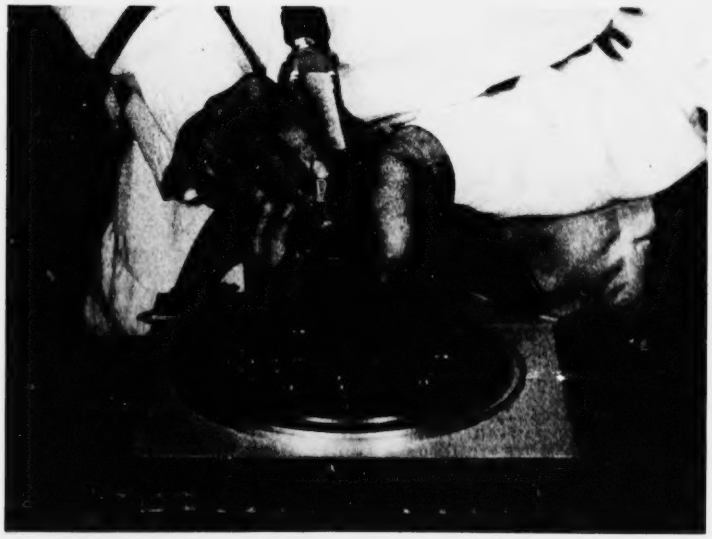
FIGURE 24

I. Position router air hose so that it will not interfere with routing operation, and rout out damaged honeycomb

   1. Position one edge of router support assembly against edge of routing template while holding router firmly and at a 45-degree angle to surface (Figure 25)

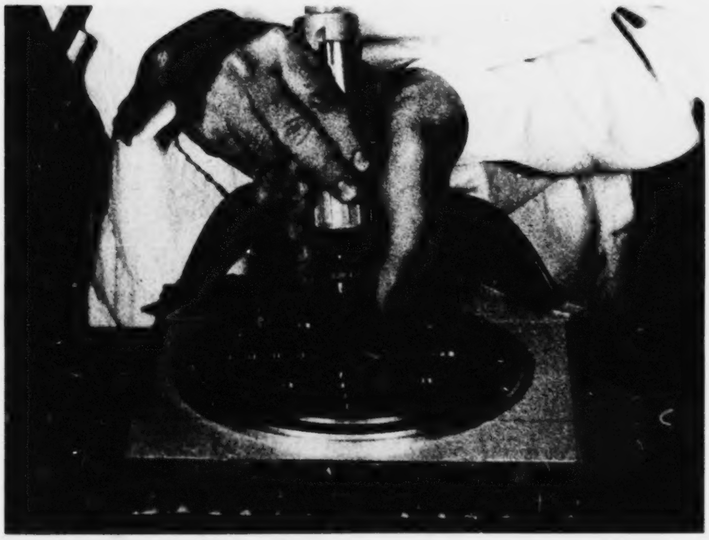
FIGURE 25



2. Start router by compressing control lever

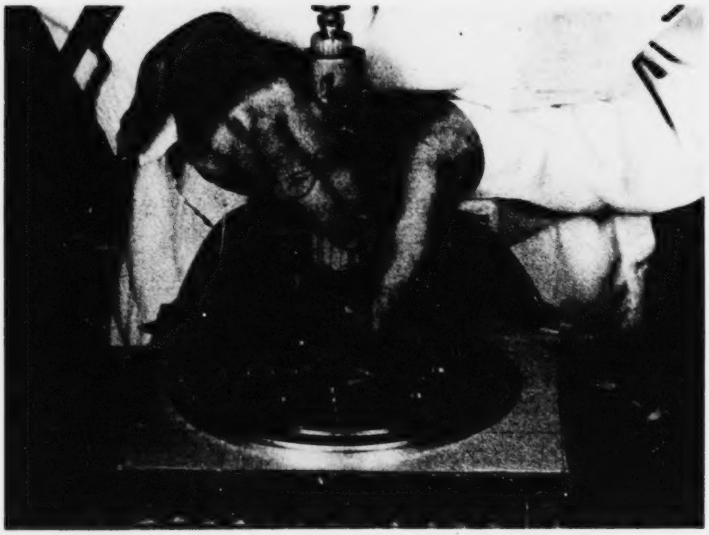
3. Carefully, but firmly, lower router bit into material as close as possible to center of damaged area to be removed (Figure 26)

FIGURE 26



4. Straighten router so that it is perpendicular to surface (Figure 27)

FIGURE 27

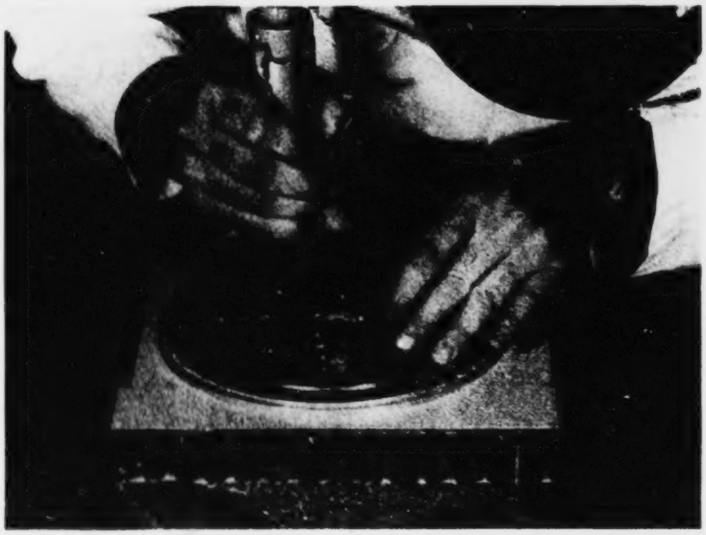


5. Holding router firmly, spiral the router clockwise to outer limits of template guide hole until all damaged material is removed (Figure 28)

CAUTION

Router must always be moved in a clockwise direction when using a right-hand-spiral mill-end router bit.

FIGURE 28



6. Release control lever and allow router to stop rotation
7. Carefully remove router bit from hole
8. Disconnect router from air supply
9. Check damaged area
10. If additional removal is required, adjust cutting depth and repeat routing operation

J. Repeat Steps A through I to remove damage from locations #2 and #3

(NOTE: Aluminum honeycomb core cells tend to bend or close up during routing operations. Therefore, they must be opened with tweezers or a pen knife before further repairs are made. All of the most common types of core cells often must be trimmed with a pen knife to the shape of the repair hole.)

K. Disconnect and clean routing equipment

L. Clean work area, and return tools and equipment to proper storage area

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PROJECT GUIDE #3 — Perform Potted Compound Repairs to Metal Bonded Honeycomb

PURPOSE: To allow you to develop skill in making potted compound repairs. You will develop skill in setting up for this type of repair and in properly mixing resins.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. Resin manufacturer's instructions

EQUIPMENT AND TOOLS:

A. Triple-beam balance scale

B. Pyrex mixing cups

C. 1/4-inch and 1/2-inch drill bits

D. Heating unit (heat lamps—250 to 300 watts), optional

E. Hand file, microshaver, or sanding disc

F. Protective clothing

G. Neoprene gloves

H. Safety glasses and face shield

I. Drill press

J. Band saw

SUPPLIES AND MATERIALS:

A. Duxseal sealing compound

B. Masking tape

C. Toothpicks

D. Preferred potting compound (potting compound #1)

E. Metal bonded honeycomb with damage removed

(NOTE: Honeycomb material which had damage removed by routing in Project Guide #2 will be used for this project.)

F. Two .250 plexiglass plates (each at least one inch larger than diameters of holes to be repaired)

G. 1/16-inch plexiglass or acetate plate (at least one inch larger than diameter of hole to be repaired)

PROCEDURE:

(NOTE: Damage to be repaired by this method will be no larger in diameter than one inch.)

WARNING

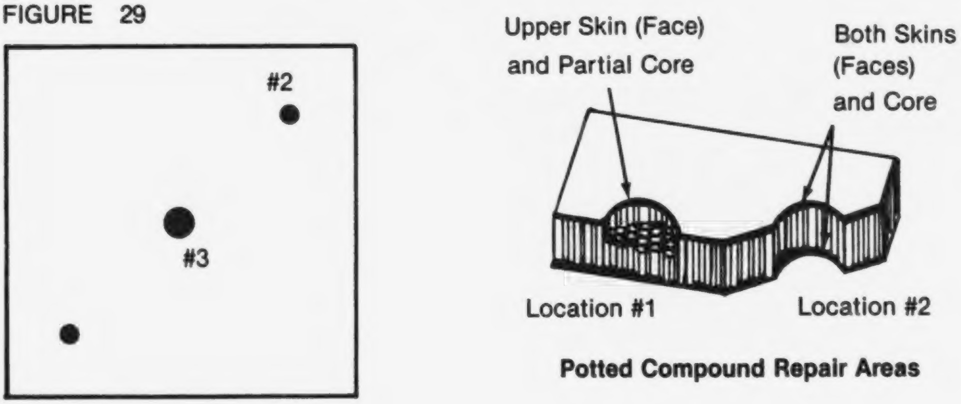
The potential of a fire hazard generally exists in the area where bonded honeycomb repairs are perfomed because of the low flash point of the repair materials, such as cleaning solvents, primers, and resins. Therefore, it is necessary that all fire precautions be observed closely. Certain fire safety prevention equipment, such as fireproof cans for solvents, flammable-waste cans, and vaporproof and explosionproof lights, should be used.

With the potential of fire hazards in a honeycomb repair area, it is necessary to make sure that a suitable fire extinguisher is on hand or is located nearby and ready for use. The extinguishing agents for all the materials used in bonded honeycomb repairs are dry chemicals or carbon dioxide; thus, the standard CO_2 fire extinguishers should be on hand for use in areas where bonded honeycomb structures will be repaired.

A. Locate damage in honeycomb panel at location #1 which is damage to upper skin and partial core (Figure 29)

(NOTE: *Skins* are also referred to as "facings")

FIGURE 29


#2
#3
Upper Skin (Face) and Partial Core
Both Skins (Faces) and Core
Location #1
Location #2

Damage Locations

Potted Compound Repair Areas

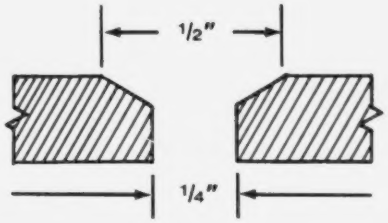
B. Prepare a .250 plexiglass plate so that it will overlap all sides of repair area by ½ inch

(NOTE: A band saw may be required at this point to cut plexiglass to proper size. Follow all applicable safety precautions. Use a metal cutting blade with six to eight teeth per inch.)

C. Drill ¼-inch hole in center of plexiglass plate

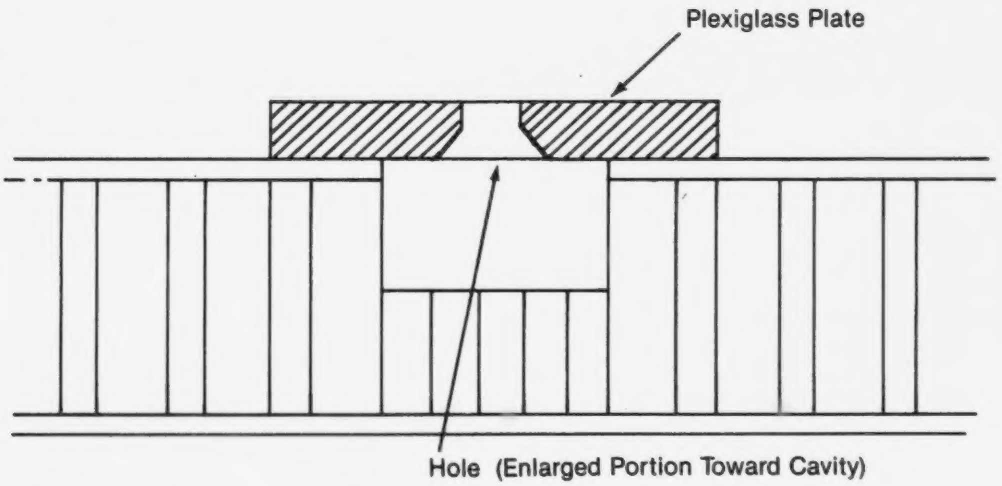
D. Drill into ¼-inch hole using ½-inch drill bit until one end of the ¼-inch hole is enlarged to ½-inch (Figure 30)

FIGURE 30



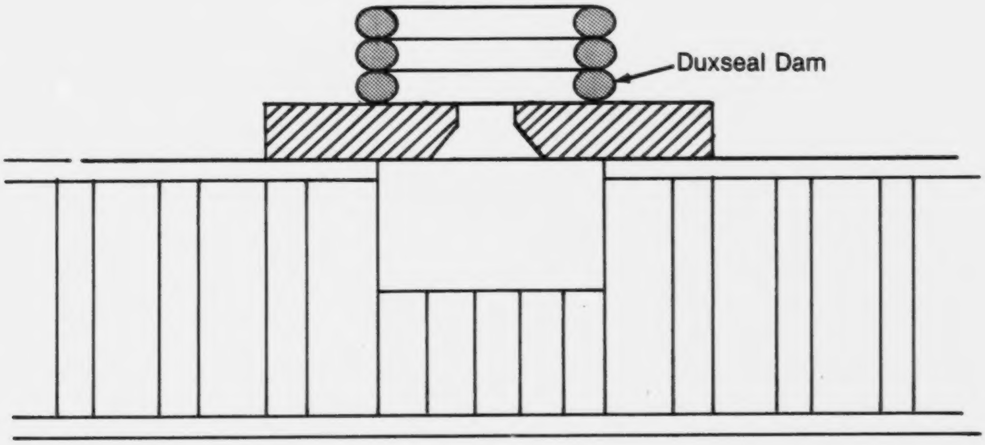
E. With enlarged portion of hole toward cavity, position, center, and tape plexiglass plate over damage (Figure 31)

FIGURE 31



F. Construct Duxseal dam around ¼-inch hole (Figure 32)

FIGURE 32



G. Prepare a batch mix of preferred potting compound

WARNING

Follow all manufacturer's safety precautions when mixing resins.

(NOTE: Repairs to upper surfaces skins will require a "thin" batch mix. Repairs to lower surfaces skins will require a "thick" batch mix.)

H. Fill repair cavity by pouring potting compound into reservoir created by Duxseal dam, and pack compound into cavity with toothpick or similar tool (Figures 33 and 34)

FIGURE 33

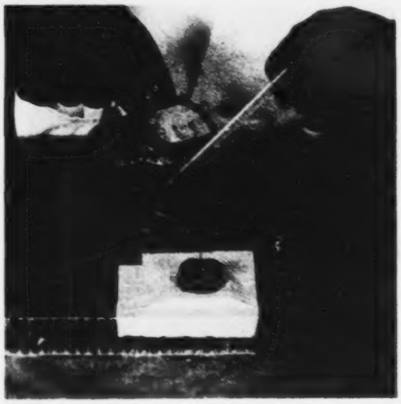
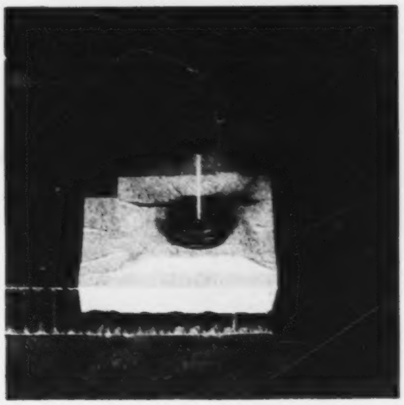


FIGURE 34



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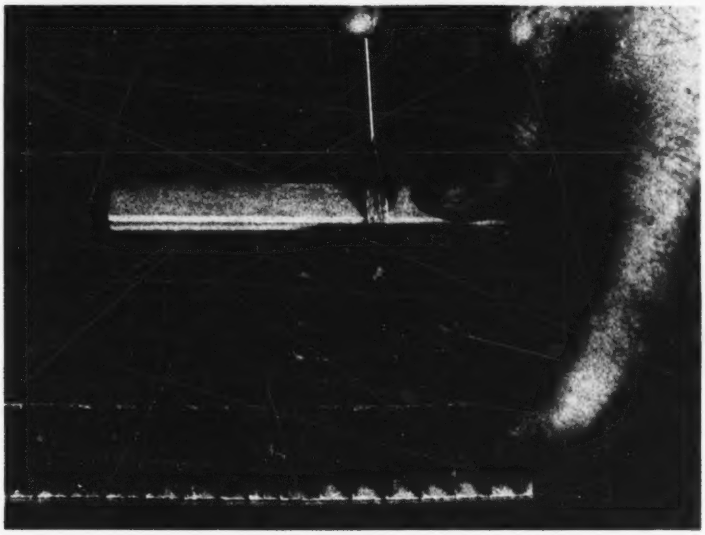
I. Cure repair a minimum of four hours at room temperature or in heating unit according to resin manufacturer's instructions

> **WARNING**
>
> **Follow resin manufacturer's safety precautions when working around high temperatures.**

J. Remove Duxseal dam and plexiglass plate (Figure 35)

(NOTE: It may be necessary to pry the plexiglass from the facing. If so, use an appropriate type of tool and be careful not to damage the facing. See Figure 35.)

FIGURE 35



K. File, sand, or microshave protruding stem, which remains after removing plexiglass, flush to surface

(NOTE: Your instructor will tell you which process to use.)

L. Locate damage in honeycomb panel at location #2 which is damage to both skins and core (See Figure 29)

M. Prepare $^{1}/_{16}$-inch plexiglass or acetate plate which will overlap $^{1}/_{2}$ inch on all sides of repair area on bottom of panel

N. Attach plexiglass or acetate plate to repair area on bottom of panel with masking tape

O. Repeat Steps B through K for location #2 on top of panel

P. Remove plexiglass or acetate plate from bottom of panel

Q. Clean work area, and return tools and equipment to proper storage area

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PROJECT GUIDE #4 — Perform Core Replacement and Glass Overlay on Metal Bonded Honeycomb

PURPOSE: To allow you to develop skill in repairing damage where the damage is in excess of one inch and core replacement with a glass overlay is required.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. AC 43.13-1A&2A

EQUIPMENT AND TOOLS:

A. Band saw

B. Scissors

C. Triple-beam balance scale

D. Pyrex mixing cups

E. Protective clothing

F. Neoprene gloves

G. Safety glasses and face shield

H. Heating unit

I. Stationary disc sander

J. Canister-type respirator

K. Fireproof can for MEK

L. 1-inch varnish brush

M. Aviation snips

N. Compass

SUPPLIES AND MATERIALS:

A. Masking tape

B. Type 38 adhesive or equivalent

C. Potting compound materials

D. Two 6" × 6" pieces of #181 fiberglass cloth

E. Two 7" × 7" pieces and one 6" × 6" piece of polyethylene film

F. MEK

G. Sandpaper (silicon carbide)

H. Felt-tip marking pencil

I. EC-776 primer

J. Cheesecloth

K. Shop rags

L. Metal bonded honeycomb with damage removed

(NOTE: Honeycomb material which had damage removed by routing in Project Guide #2 will be used for this project.)

M. 11" × 6" piece of thin sheet metal

N. Fiberglass core stock

O. Disposable plastic scrapers

PROCEDURE:

WARNING

The potential of a fire hazard generally exists in the area where bonded honeycomb repairs are performed because of the low flash point of the repair materials, such as cleaning solvents, primers, and resins. Therefore, it is necessary that all fire precautions be observed closely. Certain fire safety prevention equipment, such as fireproof cans for solvents, flammable-waste cans, and vaporproof and explosionproof lights, should be used.

With the potential of fire hazards in a honeycomb repair area, it is necessary to make sure that a suitable fire extinguisher is on hand or is located nearby and ready for use. The extinguishing agents for all the materials used in bonded honeycomb repairs are dry chemicals or carbon dioxide; thus, the standard CO_2 fire extinguishers should be on hand for use in areas where bonded honeycomb structures will be repaired.

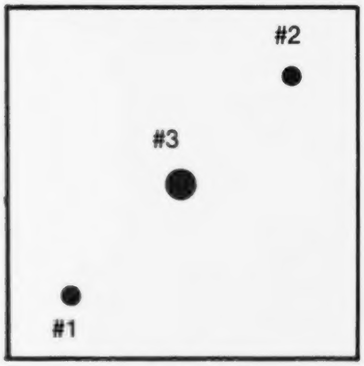
(NOTE: If any surface coatings such as paint exist on facing, they must be removed from the repair area according to manufacturer's specifications.)

PROJECT GUIDE #4

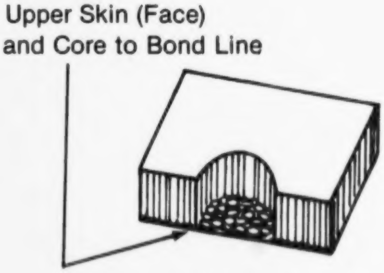
A. Locate damage in honeycomb panel at location #3 which is damage to one skin and core to bond line (Figure 36)

(NOTE: *Skins* are also referred to as "facings")

FIGURE 36



Damage Locations



Location #3

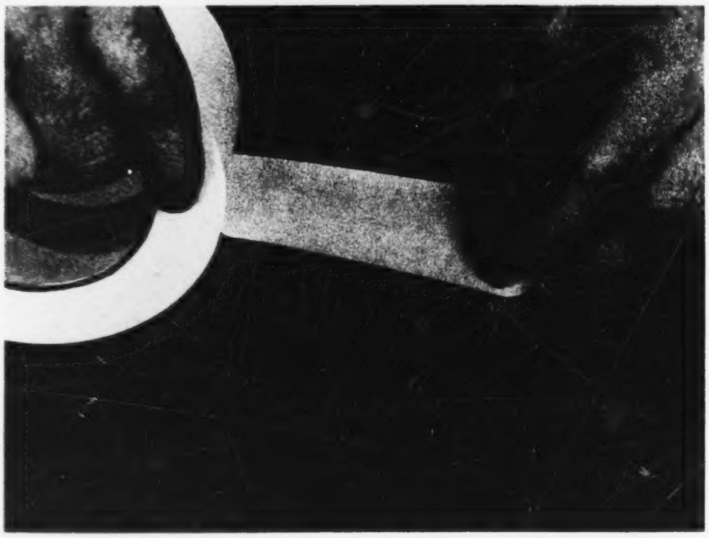
Repair Area

B. Prepare core replacement

1. Cut replacement core plug from core stock

   a. Mask area of appropriate size on top of core replacement stock using masking tape (Figure 37)

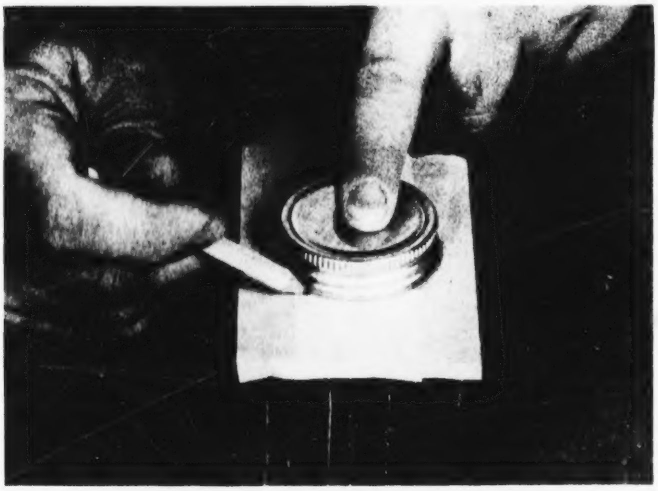
FIGURE 37



b. Draw circle with diameter slightly larger than that of repair area (Figure 38)

(NOTE: Any circular-shaped object can be used as a guide for drawing this circle.)

FIGURE 38



c. Cut out circular core replacement using band saw (Figure 39)

FIGURE 39

2. Fit plug to cavity by sanding carefully on disc sander (See Figure 40)

(NOTE: The top of the plug should be slightly above the upper skin.)

WARNING

Be sure to wear an approved canister-type respirator while sanding.

FIGURE 40

C. Prepare potting compound

1. Select desired mix for repair to be accomplished

   (NOTE: Use a thick mix for overhead repairs.)

2. Add microballoons to resin, and mix three to five minutes

3. Add curing agent to resin, and mix three to five minutes

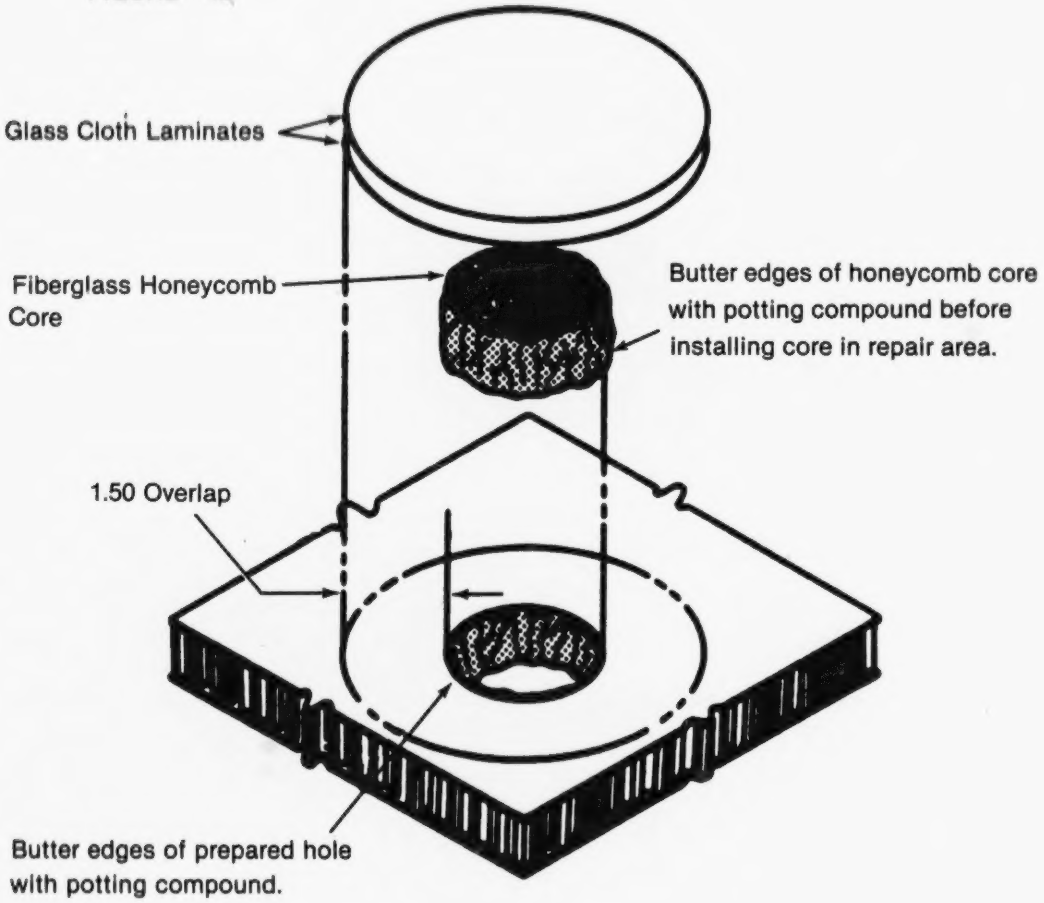
D. Apply potting compound to edges of core replacement plug and to edges of damage cutout in panel (Figure 41)

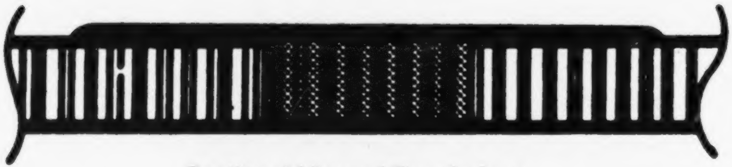
(NOTE: Use the buttering-in process. See Figure 41.)

FIGURE 41

E. Insert core plug into the repair area (Figure 42)

FIGURE 42


Glass Cloth Laminates
Fiberglass Honeycomb Core
Butter edges of honeycomb core with potting compound before installing core in repair area.
1.50 Overlap
Butter edges of prepared hole with potting compound.

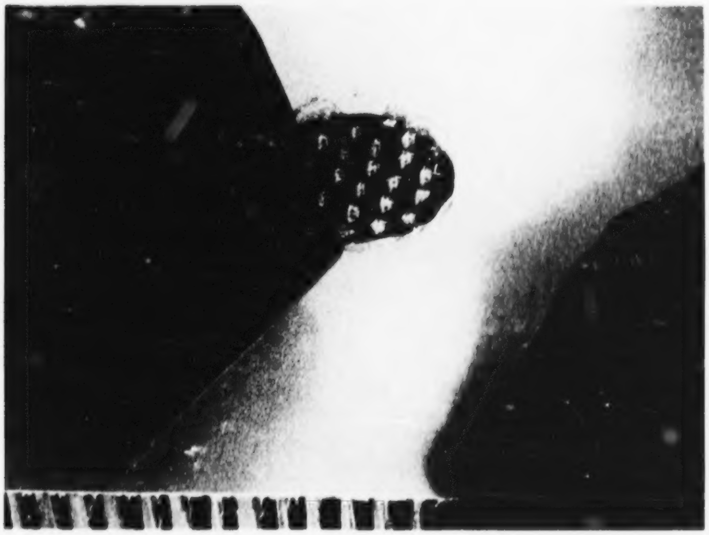


Sectional View of Repair Area

Source: EA-AC 65-15A.

F. Remove any excess potting compound on surface using plastic scraper, and clean repair area with MEK (Figure 43)

FIGURE 43



G. Allow core plug repair to cure at least one-half to one hour

H. Clean repair area thoroughly with clean cheesecloth moistened with MEK until no trace of foreign material appears

(NOTE: Do not allow MEK to dry, but wipe it off with cheesecloth.)

I. Apply adhesive primer EC-776 (or equivalent) with clean 1-inch varnish brush to faying surface area, and allow to dry

WARNING

Consult the safety data sheet on the use of EC-776.

(NOTE: Drying time is approximately one hour at room temperature [72°F]. Primer should be applied in a thin and continuous film. Brush in one direction. Do not thin primer. Primer must be dry for proper adhesion of fiberglass cloth laminates.)

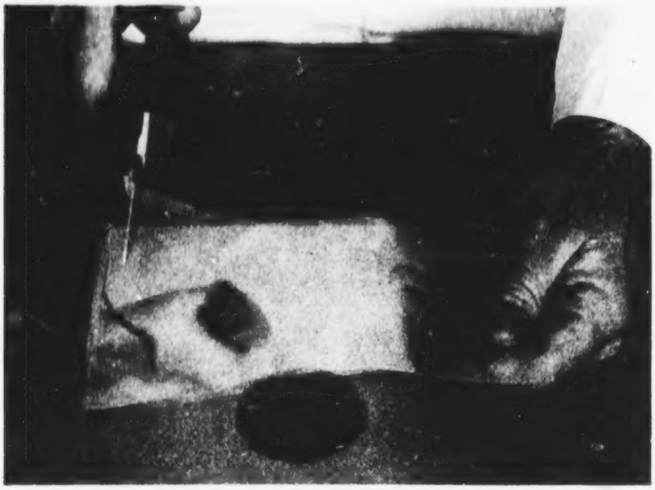
J. Prepare a clean work area, free of all foreign matter

(NOTE: This is generally accomplished by placing a clean piece of paper on a workbench.)

K. Select and cut two sheets of polyethylene film approximately 5 inches larger than damage cutout (Figure 44)

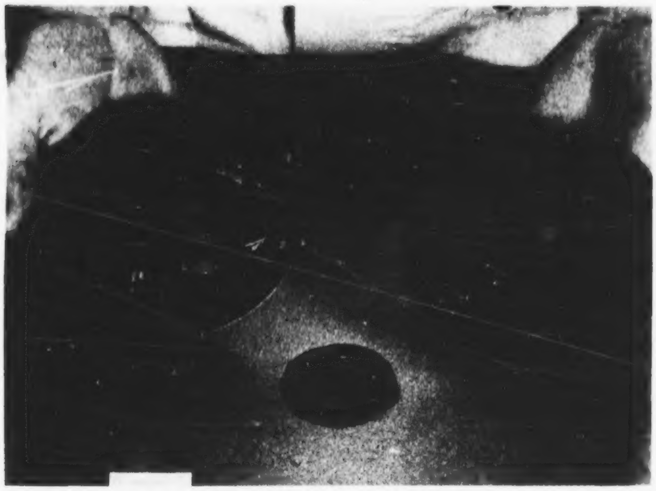
(NOTE: The 7" × 7" pieces of polyethylene are correct to use for the damage being repaired in this project. Simulated damage has been removed to a diameter of no more than 2 inches.)

FIGURE 44



L. Prepare two disc templates of thin sheet metal 3 inches larger in diameter than damage cutout for laminated overlays (Figure 45)

FIGURE 45



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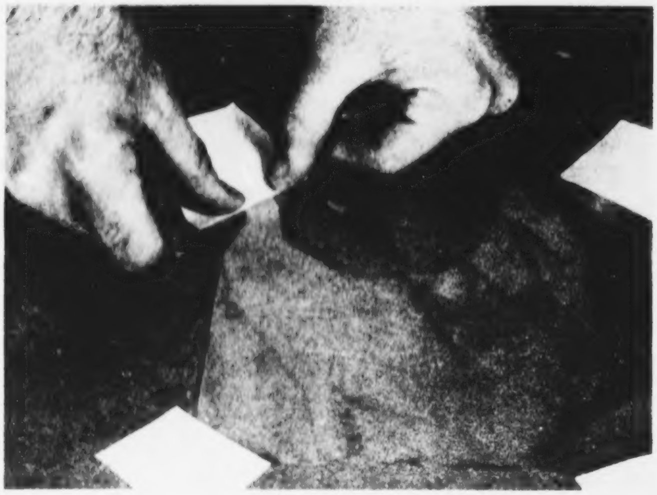
M. Prepare batch mix of type 38 adhesive or equivalent according to manufacturer's instructions

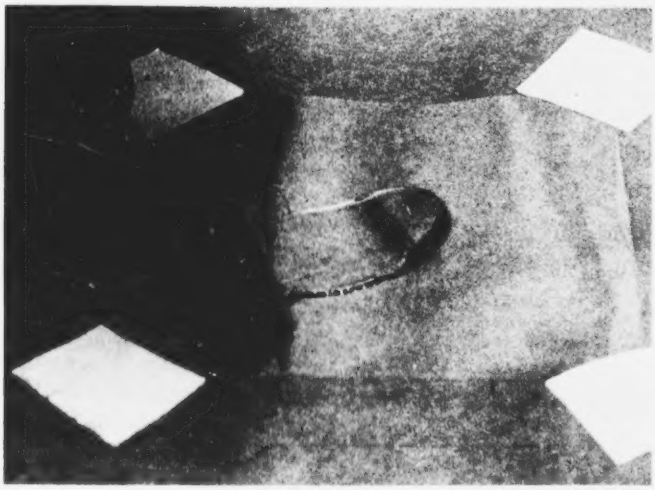
N. Place one sheet of polyethylene film on clean, paper-covered work area, and tape corners (Figure 46)

FIGURE 46



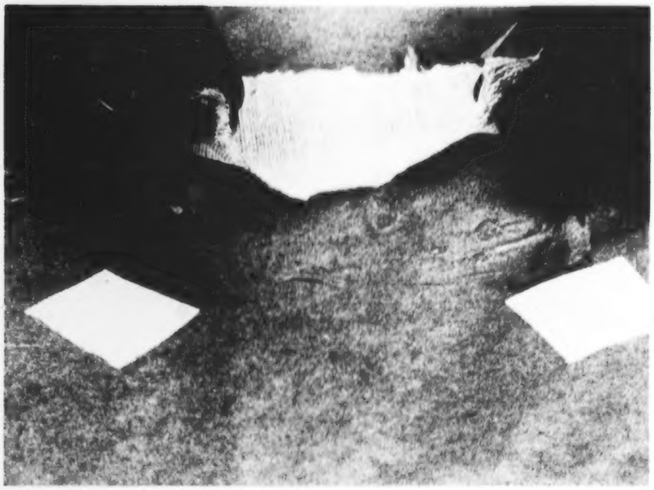
O. Pour small amount of adhesive on sheet of polyethylene film, and use plastic scraper to spread adhesive evenly over sheet (Figure 47)

FIGURE 47



P. Center and place one layer of glass fabric cloth over adhesive-covered area of sheet of polyethylene film (Figure 48)

FIGURE 48



Q. Pour an adequate amount of adhesive over layer of glass fabric cloth to cover and penetrate entire area, using plastic scraper to spread adhesive evenly over area

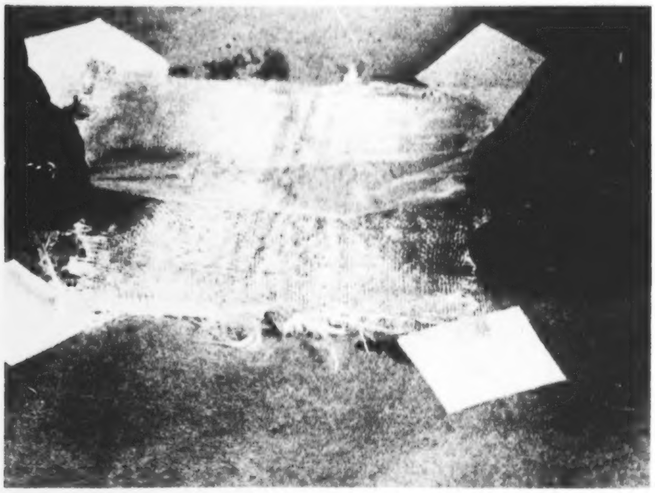
R. Repeat Step P to apply second layer of glass fabric cloth over first layer of cloth

S. Repeat Step Q to apply sufficient amount of adhesive over second layer of glass fabric

T. Place and center second sheet of polyethylene film over layers of adhesive-impregnated glass fabric cloth (Figure 49)

FIGURE 49

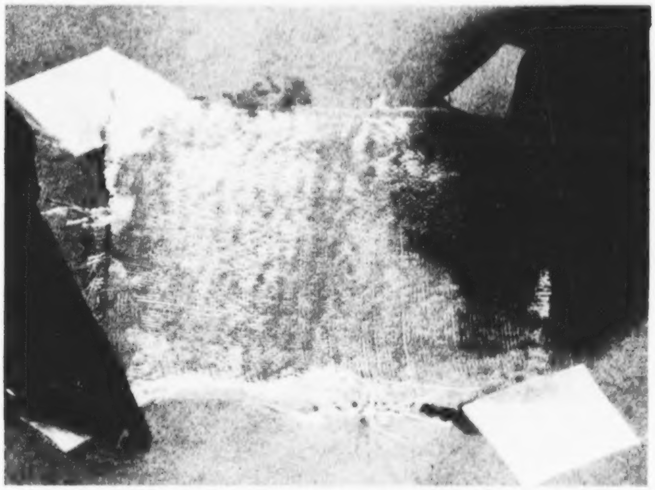
1o



U. Work out all air bubbles toward edges of laminated overlay using clean plastic scraper (Figure 50)

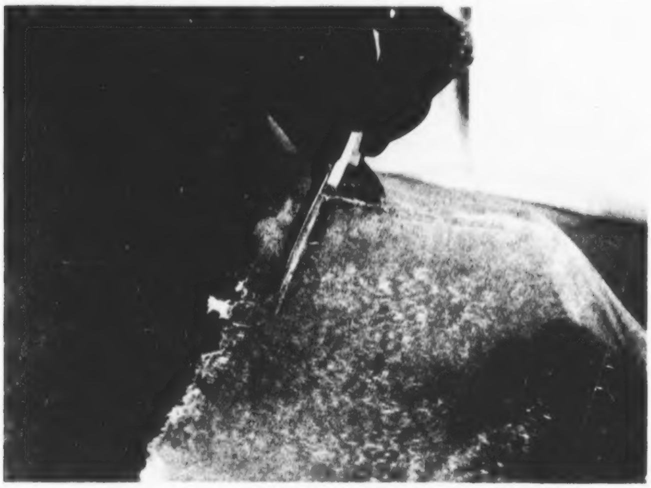
(NOTE: Turn the laminated overlay as necessary when working out the air bubbles.)

FIGURE 50



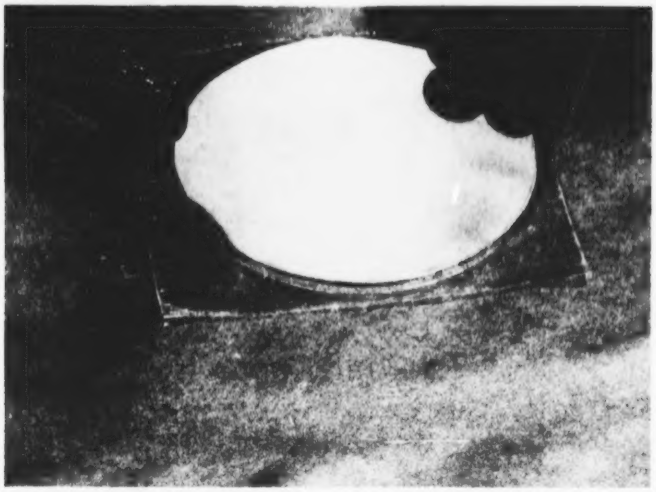
V. Use scissors to cut sandwiched polyethylene-laminated overlay 1/2 inch to 3/4 inch larger than actual size of laminated overlay (Figure 51)

FIGURE 51



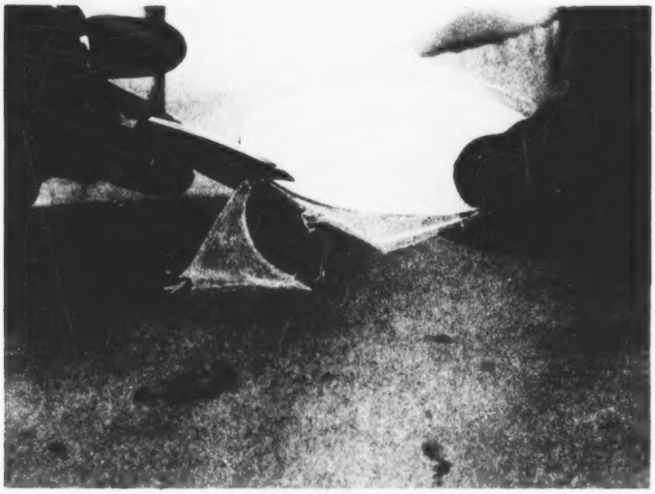
W. Place and center sandwiched polyethylene-laminated overlay between the two disc templates prepared in Step L (Figure 52)

FIGURE 52



X. Use scissors to cut laminated overlay around edge of disc templates (Figure 53)

FIGURE 53

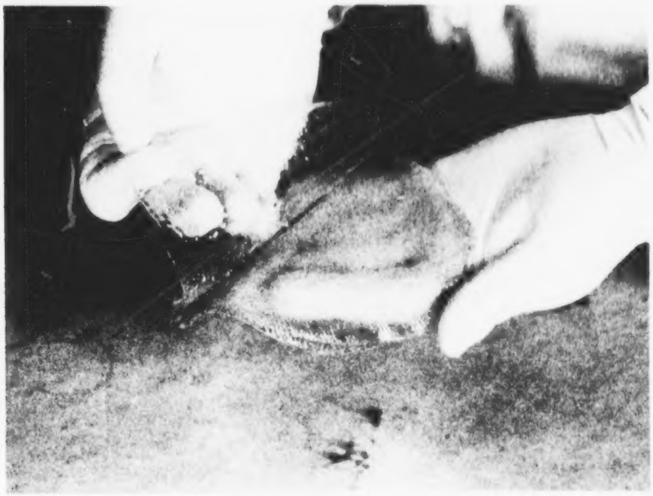


Y. Remove disc templates from sandwiched polyethylene-laminated overlay

Z. Peel off one sheet of polyethylene film from sandwiched laminated overlay (Figure 54)

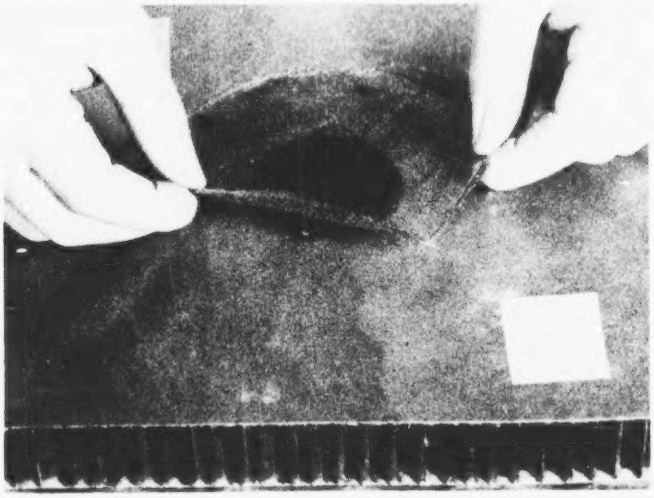
(NOTE: Discard this sheet of polyethylene film.)

FIGURE 54



AA. Place laminated overlay with exposed adhesive side down in position over repair surface area (Figure 55)

FIGURE 55



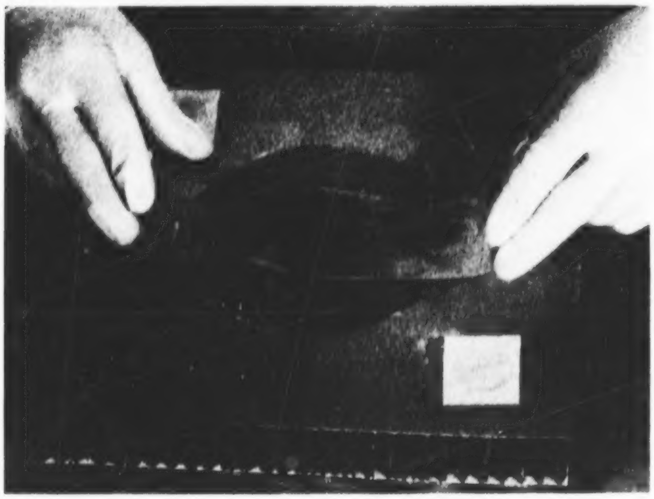
BB. Remove remaining sheet of polyethylene film from top side of laminated overlay, and discard polyethylene film

CC. Use scissors to cut another sheet of polyethylene film 3/4 inch to 1 inch larger than laminated overlay

(NOTE: The 6″ × 6″ piece of polyethylene film is correct to use for this step.)

DD. Place and center sheet of polyethylene film over laminated overlay (Figure 56)

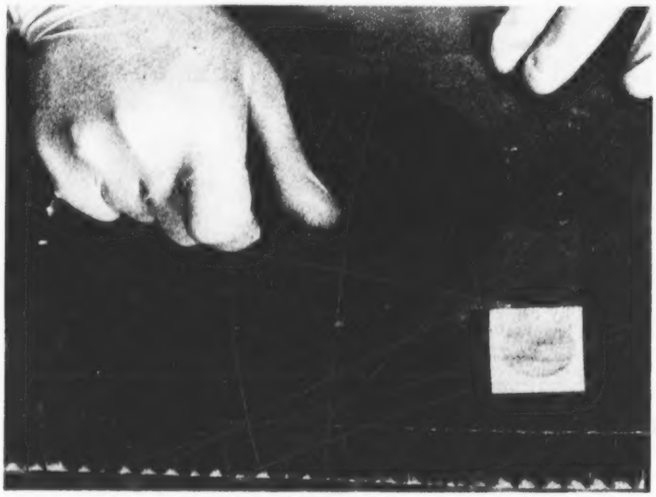
FIGURE 56



EE. Use smooth, clean plastic scraper to sweep out any excess resin or air bubbles that may be present within laminated overlay (Figure 57)

(NOTE: This step is extremely important to the overall quality of the repair. Therefore, this step should be accomplished with the greatest of care and patience. It may be desirable to tape one end of the polyethylene film to prevent the film from bunching when using plastic scraper.)

FIGURE 57



FF. Clean surrounding area of repair with MEK

(NOTE: Take care to prevent any of the cleaning solvent from entering the bond of the repair area.)

GG. Allow laminated overlay repair to cure at least 12 hours at room temperature (72°F)

HH. Remove final sheet of polyethylene film

II. Clean work area, and return tools and equipment to proper storage area

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
A201-C

THEORY TEST

1. Match terms related to bonded structures to their correct definitions. Write the correct numbers in the blanks.

_____a. Chemical change which takes place in a finishing system which produces the desired surface

_____b. Material which is used to bring about a change, but does not actually enter into the change itself

_____c. Substance added to resin to increase its resistance to flow

_____d. Flexible thermosetting resin made by polymerization of an epoxide; used chiefly in coatings and adhesives

_____e. Resin material which will soften with the application of heat

_____f. Structure whose parts are joined together by chemical methods rather than mechanical

_____g. Synthetic resin, usually reinforced with fiberglass cloth or mat, used to form complex shapes for aircraft structure

_____h. Resin that usually sets by chemical means and maintains its hardness even when heat is applied

_____i. Substance which combines with epoxy resin to initiate the curing of the material

_____j. Substance added to a catalyzed resin to shorten the time required for the resin to cure

_____k. Substance used on a mold to prevent bonding of the resin to the mold

_____l. Composed of thin layers of material firmly bonded or united together

_____m. Poisonous

1. Polyester resin
2. Thixotropic agent
3. Bonded structure
4. Accelerator
5. Cure
6. Epoxy resin
7. Thermoplastic resin
8. Catalyst
9. Curing agent
10. Thermosetting resin
11. Laminated
12. Release agent
13. Toxic

THEORY TEST

______n. Agent added to a resin to retard its curing and increase its shelf life

______o. Extremely thin fibers of glass used to reinforce epoxy or polyester resin for aircraft structure

______p. Single thread

______q. Separation of the core and face sheets of a bonded structure along a bond line

______r. Hexagonal cellular material made of thin metal, paper, or plastic; used as a core material for sandwich structure

______s. Orientation or alignment of the longitudinal axis of the fiber with respect to a stated reference axis

______t. Adhesive in sheet-like form that comes in various thicknesses with a backing film, heat cured

______u. Time span a plastics product will remain fit for use

______v. Length of time at room temperature before a catalyzed resin has polymerized (hardened) to an unworkable state

______w. Combination of distinct parts which are put together to form a compound

______x. Sticking together of particles of a substance held together by valence forces

______y. Single homogeneous strand of material; used as the principal constituent in advanced composite

______z. Stage when a polymerizing resin composition thickens to a semisolid form

14. Honeycomb
15. Inhibitor
16. Fiberglass
17. Delamination
18. Filament
19. Shelf life
20. Cohesion
21. Pot life
22. Film adhesive
23. Fiber
24. Fiber direction
25. Composite
26. Gel

THEORY TEST

______aa. Substance, usually a liquid, used for dissolving/cleaning materials during reinforced plastics operations

______bb. Volatile liquid used as a solvent for organic compounds

______cc. Glue, paste, or film-type substance that when applied to two matting surfaces is capable of holding them together by surface attachment

______dd. Adhesives in container form, usually a two- or three-part mix, applied with brush or spatula, air or heat cured

______ee. Adhering or sticking together of substances in contact with each other

27. Acetone
28. Adhesion
29. Adhesive
30. Paste adhesive
31. Solvent

2. Safety is the foremost consideration which should be given to any repair procedure. State eight general safety rules to observe when repairing or fabricating bonded structures.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

e. ____

____

f. ____

____

g. ____

____

h. ____

____

THEORY TEST

3. Match materials related to fiberglass and composite bonded structure repair to their correct usages and characteristics. Write the correct numbers in the blanks.

______a. Used strictly for mat molded fiberglass parts and laminated glass cloth structures including fiberglass honeycomb enclosures

______b. Material that looks like two- to three-inch white strands pressed to form a loose blanket; the strands have no pattern, and in uncured stage looks quite porous

______c. Materials used to expose the surface and give visual access to underlying plies

______d. Glass which is spun into yarn and then made into glass fabric; has the texture and look of wool cloth, but has a glassy appearance like satin

______e. Commonly used as adhesives that when mixed produce a liquid that will flow between the fiberglass; produces a hard, plastic-like surface when cured

______f. Chemical compound used in a polyester resin mixture to speed up or hasten the chemical reaction caused by addition of the catalyst (sometimes called a promoter)

______g. Water-soluble plastic material used as a parting agent during the curing process; it can be easily removed from the repair when necessary

______h. Plastic film used on overlays and where pressure may not be applied; will not stand up to high heat, is not affected by moisture, and will not stretch as easily as PVA

______i. Materials that will not bond to the resin as it cures

______j. Agent added to resins in required amounts to control the viscosity

______k. Chemical compound usually added last to a polyester resin mixture to cause it to harden

______l. Short, loose fibers that are mixed directly into the resin and are useful in areas that have complicated shapes; made from fiberglass material and used most often for molded constructions

______m. Used to give repair hardness and produce the bond

______n. Used to stabilize the core of nylon honeycomb

1. Polyvinyl alcohol (PVA film)
2. Epoxy resin system
3. Paint removers and cleaners
4. Polyester resin system
5. Accelerator
6. Woven glass cloth
7. Mat binder
8. Chopped fibers
9. Thixotropic agent
10. Polyethylene (PE) film
11. Catalyst
12. Parting/release agents
13. Resin
14. Phenolic resin system

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THEORY TEST

4. Match materials related to metal bonded honeycomb structure repair to their correct usages. Write the correct numbers in the blanks.

______a. Parting agent used with epoxy resins only

______b. Epoxy resin system used with fiberglass cloth when fabricating overlay repair to metal bonded honeycomb

______c. Material sprayed on bonded honeycomb repair areas for protection against erosion and corrosion

______d. Cloth woven from fibers made of spun glass which is used in overlay repairs to bonded honeycomb structures

______e. Type of compound used to repair bonded honeycomb structures; holes up to one inch in diameter are sometimes repaired by using this material in a process called a *hole-filling technique*

______f. Used on metal surfaces to be bonded; works with adhesive to create a better bond

______g. Aluminum pigmented erosion and corrosion preventive which can be either sprayed or brushed on bonded honeycomb repairs

______h. Compound used around a hole to be repaired in a bonded honeycomb structure; acts as a reservoir to ensure adequate filling with potting compound

1. Duxseal sealing compound
2. Adhesive primer
3. Type 38 adhesive
4. Primer
5. Polyethylene (PE) film
6. Corrogard (EC843)
7. Potting compound
8. Glass fabric

5. Select true statements related to types and characteristics of bonded structures. Write a "T" in the blanks before the correct answers.

______a. Fiberglass assemblies are better than metal assemblies where electrical wave transmission is needed

______b. Fiberglass breaks exactly like glass, but is more resistant to high temperature

______c. Fiberglass is very useful in the construction of parts with complex compound curves

______d. Preformed, mat molded, solid laminate, and sandwich construction are the most common types of assemblies found in fiberglass construction

______e. A solid laminate type of assembly has two or more layers of glass cloth bonded together with resin under heat and pressure

THEORY TEST

______f. Preformed fiberglass assemblies have a core to which face plies of glass cloth are bonded

______g. Metal bonded honeycomb structure has superior strength-to-weight ratio over conventional structures

______h. Metal bonded honeycomb structure has a relatively low cost when compared to conventional structure

______i. Three areas found on honeycomb panels are the bay area, the transition area, and the flange area

______j. The most commonly used facings for metal bonded honeycomb panels are 2024-T3 and 7075-T6

______k. Core material for metal bonded honeycomb structure is made by forming processes called corrugation and expansion

______l. Exposure of honeycomb structures to sonic vibrations usually causes delaminations

______m. Composites are combinations of materials differing in composition or form

______n. When replacing aluminum structure with graphite/epoxy composite structure, weight reductions of more than 10 percent are uncommon

6. The aviation maintenance technician must be able to plan a repair to a bonded structure and must have a thorough knowledge of repair procedures to perform the repair. Discuss work procedures related to repairing fiberglass and composite bonded structures by answering the following questions.

   a. 1) What consideration should be given to a repair where there will be a variation in a cross-sectional area?

      2) What would be the result of failing to observe this repair consideration?

   b. What should be done to determine the effectiveness of the epoxy adhesive used to repair these types of bonded structures?

THEORY TEST

c. How can scratches which occur on the surface of a fiberglass laminate be repaired?

____

____

d. How is bonded fiberglass honeycomb repaired when the damage extends through one facing and into the core?

____

e. When preforming a tap test on fiberglass laminate, how would a delaminated area be detected?

____

7. Describe how the tap test and visual inspection are accomplished on fiberglass and composite bonded structures.

Tap test

____

____

____

____

Visual inspection

____

____

____

____

THEORY TEST

8. Match the classes of repairs to fiberglass bonded honeycomb to their correct types of damage. Write the correct numbers in the blanks.

______a. Punctures through at least one ply and possibly into the core

______b. Erosion from rain and other weather conditions

______c. Delaminations

______d. Moisture contamination

______e. Oil contamination

______f. Damage to outer ply only

______g. Scars from handling or storage

______h. Fractures extending through at least one ply and possible damage to the core

______i. Damage extending completely through the sandwich

______j. Scratches on the surface of the outer ply only

1. Class I
2. Class II
3. Class III

9. Match the types of inspection techniques to the specific types of metal bonded honeycomb damage. Write the correct numbers in the blanks. Some questions may have more than one answer, and some answers may be used more than once.

______a. Delamination between the core and inner or outer skin

______b. Scratches on aluminum surface panels

______c. Punctures and dents

______d. Cracks

______e. Wing understructure inspection

______f. Nonstandard bonds, voids, and other similar defects

1. Visual or thumb-pressure test
2. Visual inspection
3. Caustic soda solution test
4. Panel inspection analyzer
5. Metallic ring test
6. Boroscope

THEORY TEST

10. Match the classes of metal bonded honeycomb damage to their correct types of damage. Write the correct numbers in the blanks.

______a. A gouge in one skin in which the core is damaged

______b. The skin has oilcanned away from the core with no damage to the core

______c. Both skins and the core are damaged

______d. There is a dent in one skin in which the core is damaged

______e. A scratch that does not penetrate the skin

______f. A tear in one skin in which the core is not damaged

______g. A nick in the outer skin that does not go through the skin

______h. Delamination of one skin in which the core is damaged

______i. A dent in one skin in which the core is not damaged

______j. A hole in one skin in which the core is not damaged

______k. There is a tear in one skin, the core is damaged, and a puncture in the other skin

1. Class I
2. Class II
3. Class III
4. Class IV

11. Select from the following list repair techniques that will ensure defect-free repairs. Circle the letters before the correct answers.

a. In all composite repairs, it is important to determine the direction of the warp in the original facings so the direction of the warp in the replacement layers can be made to match in each ply

b. After the repair has been assembled, do not apply heat to the area which is curing

c. Punctured facings, delaminations, oil contamination, and fractured core in all areas must be repaired by removal of all damaged material and replacement with approved materials of the same thickness as the original

d. Patches which protrude above the surface of the aircraft's skin are most desirable because they do not allow a boundary layer of air to form

e. Make all small patches round, oval, or with rounded corners instead of square or rectangular

f. Avoid abrupt changes in cross-sectional areas by tapering joints; abrupt changes may cause dangerous stress concentration

g. Uniformity in core thickness, facings, and density and cell size of core are extremely important

h. When repairing nonstructural components such as fairings, the primary consideration is that weight is added to the structure at the point where the repair is made

i. Use approved materials and working techniques to repair damaged parts

j. Avoid patches that project above the original surface; be sure the outside surface of high-speed aircraft is smooth to ensure proper performance

12. Match tools and equipment used in metal bonded honeycomb structure repair to their correct uses. Write the correct numbers in the blanks.

_____a. Attachment which threads onto the router body with provisions for adjusting the desired depth of cut with a locking (clamping nut) mechanism

_____b. Guide used in conjunction with the router and support assembly to remove various sizes, shapes, and contours of damaged honeycomb areas

_____c. Source of electrically heated air used to cure sealants, adhesives, and repair compounds; has an approximate temperature range of 150°F to 500°F

_____d. Devices used to hold materials and resins in place until repair is cured

_____e. Device used to ensure accurate mixing of ingredients in adhesives and compounds

_____f. Devices used to support, align, and hold the template in proper position during the cutting operation

_____g. Document which provides information pertaining to allowable repairs and techniques for aircraft

1. Scales
2. Heat gun
3. Router support assembly
4. Template
5. Pressure jigs
6. Wedge blocks
7. Manufacturer's maintenance or structural manual

______h. Device used to shorten curing time

______i. Device used to detect and indicate the intensity of combustible gases in the repair area

______j. Device used to remove damaged sections of honeycomb structures

______k. Adhesive that is used to hold down the template and bridges to allow use of the router

______l. Device placed on an area to provide a source of heat, thermostatically controlled

8. Double-backed tape
9. Router
10. Heating blanket
11. Explosive meter
12. Infrared lamp

13. Select statements pertaining to repair procedures when given data related to metal bonded honeycomb repairs. Circle the numbers before the correct answers.

a. Honeycomb core material used to replace damaged aluminum cores of honeycomb bonded structures is usually

1) titanium

2) fiberglass

3) stainless steel

4) magnesium

b. In a transition area bonded honeycomb panel repair, the circular shape repair should not exceed

1) 2 inches in diameter

2) twice the bay area thickness

3) five times the flange area thickness

4) 5 inches in any direction

c. A typical repair used to retain 100 percent strength to a damaged area 1 inch in diameter of bonded honeycomb is

1) a step-type metal facing patch

2) an overlap-type metal facing patch

3) a scarf-type facing patch

4) an overlap-type resin-glass facing patch

d. When balsa wood is used to replace a damaged honeycomb core, the plug should be cut so that

1) the grain is parallel to the skin

2) it will be slightly compressed when the repair is completed

3) it is about 1/8 inch undersize to allow sufficient bonding material to be applied

4) the grain is perpendicular to the skin

e. A potted compound repair on honeycomb can usually be made on damages less than

1) 3 inches in diameter

2) 2 inches in diameter

3) 4 inches in diameter

4) 1 inch in diameter

f. When repairing puncture-type damage of a metal faced laminated honeycomb panel, the edges of the doubler should be tapered

1) two times the thickness of the metal

2) five times the thickness of the metal

3) 100 times the thickness of the metal

4) to whatever is desired for appearance

g. When making repairs to laminated honeycomb panels, microballoons are sometimes used to

1) Speed up the curing process by allowing air to circulate around the molecules

2) lower the density and provide greater flexibility

3) serve as a blocking agent to prevent the uncured resin from entering the honeycomb

4) Slow down the curing process to allow a longer working time

THEORY TEST

(NOTE: Test question 14 is a workbook supplement. It is an important part of this test. If it has not been completed, check with your instructor.)

14. Discuss characteristics of boron and graphite materials

(NOTE: Test questions 15-18 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

15. Repair surface scratches in fiberglass laminate.

16. Remove damage from metal bonded honeycomb with a router.

17. Perform potted compound repairs to metal bonded honeycomb.

18. Perform core replacement and glass overlay on metal bonded honeycomb.

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR BONDED STRUCTURES
A201-C

ANSWERS TO THEORY TEST

1\.
a. 5
b. 8
c. 2
d. 6
e. 7
f. 3
g. 1
h. 10
i. 9
j. 4
k. 12
l. 11
m. 13
n. 15
o. 16
p. 18
q. 17
r. 14
s. 24
t. 22
u. 19
v. 21
w. 25
x. 20
y. 23
z. 26
aa. 31
bb. 27
cc. 29
dd. 30
ee. 28

2. Answer should include any eight of the following

a. Avoid breathing dust and chemical fumes from composite materials, and wear an approved respirator when grinding, sanding, or working around composite material or any type of work involving chemicals
b. Wear protective clothes and discard when finished grinding or sanding
c. Work in a manner that will produce a minimum amount of dust
d. Work in a well-ventilated area
e. Use the proper type of eye and face protective apparel
f. Use the proper type of protective cream or gloves for your hands
g. Wear a face mask and ear plugs when routing
h. Have ready access to appropriate fire-fighting equipment
i. Know the chemicals you are working with; if they are not labeled, DO NOT use them
j. Dispose of flammable wastes and reusable shop rags contaminated with chemicals in fireproof containers
k. Use only explosionproof lights in repair or fabrication areas
l. Use an explosive meter to monitor areas where chemical fumes concentrate
m. Never use a chemical without first consulting the safety data sheet and the container label
n. Make sure metal bonding materials are segregated from composite bonding materials

3\.
a. 4
b. 7
c. 3
d. 6
e. 2
f. 5
g. 1
h. 10
i. 12
j. 9
k. 11
l. 8
m. 13
n. 14

4\.
a. 5
b. 3
c. 4
d. 8
e. 7
f. 2
g. 6
h. 1

5. a, c, d, e, g, h, i, j, k, l, m

ANSWERS TO THEORY TEST

6. a. 1) Avoid abrupt changes in cross-sectional areas
   2) A dangerous stress concentration would develop
   b. Prepare a test specimen at the same time the repair is accomplished using the same adhesive batch mixture, curing pressure, temperature, and time identical with those in the actual repair; perform a destructive test when the test sample is ready
   c. By applying one or more coats of suitable resin (room temperature catalyzed) to the surface
   d. By replacing the damaged core and facing
   e. By a dull, flat sound

7. Description should include the following

   Tap test

   a. Lightly tap damaged area, and listen for change in sound
   b. Tap test suspected damaged area until damage borders are defined

   Visual inspection

   a. Remove any surface coatings which hinder visual inspection
   b. Evaluate the extent of damage further by using a strong light source

8. a. 2
   b. 1
   c. 2
   d. 2
   e. 2
   f. 1
   g. 1
   h. 2
   i. 3
   j. 1

9. a. 1, 5
   b. 3
   c. 2
   d. 2
   e. 6
   f. 4

10. a. 3
    b. 2
    c. 4
    d. 3
    e. 1
    f. 2
    g. 1
    h. 3
    i. 1
    j. 2
    k. 4

11. a, c, e, f, g, i, j

ANSWERS TO THEORY TEST

12. a. 3
    b. 4
    c. 2
    d. 5
    e. 1
    f. 6
    g. 7
    h. 12
    i. 11
    j. 9
    k. 8
    l. 10

13. a. 2
    b. 1
    c. 2
    d. 4
    e. 4
    f. 3
    g. 2

14. Evaluated to the satisfaction of the instructor

15. Performance skills evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

17. Performance skills evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor

MODULE OF INSTRUCTION
FOR
AVIATION MAINTENANCE TECHNOLOGY

AIRFRAME

A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

INSPECT AND REPAIR TRANSPARENT PLASTIC MATERIALS

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INTRODUCTION

The optical qualities of the transparent material used in aircraft enclosures must be as good as those of the best quality plate glass. The ability to locate other aircraft in flight and to have the positive depth perception necessary to land safely, to a large degree, depends on the care given to the aircraft enclosures. Therefore, as an aviation maintenance technician, you will be required to inspect, repair, and maintain transparent plastic aircraft enclosures.

MODULE OBJECTIVE

After completion of this module, you will be able to cut and form acrylic plastic, repair shallow surface scratches in plastic, and make a temporary repair to plastic. You will also be able to repair transparent plastic with a surface patch. Your competency will be evaluated by completing workbook assignments, project guides, and by scoring a minimum of 85 percent on the module theory test.

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SPECIFIC OBJECTIVES

After completion of this module, you will be able to:

1. Match terms related to transparent plastic materials to their correct definitions. (1)	Technical Supplement #1	
2. Specify the type or class of transparent plastics when given the characteristics of the types and classes. (2)	Technical Supplement #2 AC 65-15A Workbook Supplement #1 EA-ITP-AW	 213 1:III:13
3. Identify transparent plastic materials by matching plastics to MIL specification numbers or the results of plastic identification tests. (2)	Technical Supplement #3 EA-ITP-AB AC 65-15A Workbook Supplement #1 EA-ITP-AW EA-ITP-ASG	 68 214 1:III:13 8:55
4. Select the proper procedures to employ when storing transparent plastics. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #2 EA-ITP-AW	68 214-215 1:III:13
5. State general rules to follow when handling transparent plastic materials. (1)	AC 65-15A	213-214
6. State the appropriate work procedures for transparent plastics when given data related to forming, cutting, and drilling. (2)	EA-ITP-AB AC 65-15A Technical Supplement #4 Workbook Supplement #3 EA-ITP-AW EA-ITP-ASG	68-71 215-217 1:III:14 8:56, 58-62
7. Describe the two methods of cementing acrylic plastics. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #3 EA-ITP-AW EA-ITP-ASG	71-72 217-218 1:III:14 8:57
8. State general safety rules to follow when working with plastic and plastic adhesives. (1)	Technical Supplement #5	

SPECIFIC OBJECTIVES

9. Cut and form acrylic plastic. (3)	Project Guide #1	
10. Discuss the curing process of acrylic plastic cemented joints. (2)	EA-ITP-AB AC 65-15A Workbook Supplement #3 EA-ITP-AW EA-ITP-ASG	72 218 1:III:14 8:63
11. State procedures and precautions to follow when repairing surface scratches in acrylic plastic when given related data. (2)	EA-ITP-AB	73
12. Repair shallow surface scratches in plastic. (3)	Project Guide #2	
13. Select true statements related to the care and maintenance of transparent plastics. (1)	EA-ITP-AB AC 65-15A EA-ITP-ASG	72-74 218-220 8-9:64-66
14. Make temporary repair to plastic. (3)	Project Guide #3	
15. Repair transparent plastic with a surface patch. (3)	Project Guide #4	
16. State the causes of specific defects found in transparent plastic. (1)	Technical Supplement #6	
17. State the reasons for specific procedures and precautions to follow when removing and replacing transparent plastic assemblies. (1)	EA-ITP-AB AC 65-15A AC 43.15-1A&2A Technical Supplement #7 EA-ITP-AW EA-ITP-ASG	74 220-221 159-160 1:III:13-14 9:67

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INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

I. Order materials to supplement module:

A. Booklets

1. *Maintenance and Restoration of Aircraft Acrylic Transparencies with Micro-Mesh Cushioned Abrasives*

   (NOTE: This booklet is required for Project Guide #2. It can be obtained free of charge from Micro-Surface Finishing Products, Inc., Box 818, Wilton, Iowa 52778.)

2. Rohm and Haas fabrication booklets

   a. *Acrylic Sheet General Information*, PL-1p
   b. *Cutting Plexiglas Sheet*, PL-2
   c. *Matching Plexiglas Sheet*, PL-3
   d. *Thermoforming Plexiglas Sheet*, PL-4
   e. *Cementing Plexiglas Sheet*, PL-7
   f. *Maintenance of Plexiglas Sheet*, PL-8
   g. *Finishing Plexiglas Sheet*, PL-9
   h. *Annealing Plexiglas Sheet*, PL-10
   i. *Painting Plexiglas Sheet*, PL-52
   j. *Strip Heating Thick Sections of Plexiglas Sheet*, PL-957
   k. *Plexiglas MC Sheet Fabrication and Thermoforming Manual*, PL-1367
   l. *Sources of Supplies—Plexiglas Sheet*, PL-15r
   m. *Plexiglass Design and Fabrication Data*, PL-7N

   (NOTE: These booklets will be used throughout this module. They should be made available in your aviation technical library. They are available from Rohm and Haas, Independence Mall West, Philadelphia, PA 19105. Telephone 215-592-3000.)

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B. Videotape — *Training Film For Maintenance and Restoration of Aircraft Acrylic Transparencies with Micro-Mesh Cusioned Abrasives*

(NOTE: This videotape is available from Micro-Surface Finishing Products, Inc., Box 818, Wilton, Iowa 52778.)

II. Implementation Suggestions

(NOTE: Have students read all available resource material related to specific objectives.)

Estimated Teaching Time		Theory	Lab
Objective 1	Explain the terms and definitions related to transparent plastics. Use visual aids as much as possible during your discussion. For example, try writing each word in very large capital letters on the board prior to giving your explanation. Use Technical Information Supplement #1.		
Objective 2	Use Technical Information Supplement #2 and a chart such as Instructional Supplement #1 to explain the types, classes, and associated characteristics of the plastics to be studied in this module.		
Objective 3	Explain how plastic material can be recognized by MIL-Spec numbers and by the various identification tests which can be performed in the field. Use Technical Information Supplement #3. Have examples of the various types of plastic materials on hand for the students to examine. Also have materials on hand to perform an identification demonstration for both acetate and acrylic plastics. Make sure all applicable safety precautions are followed when handling solvents and chemicals. Have students complete Workbook Supplement #1.		
Objective 4	Explain the proper procedures which are employed in the storage of plastics. Use Transparency Masters #1 and #2. Have students complete Workbook Supplement #2.		

INSTRUCTOR'S MODULE IMPLEMENTATION GUIDE

Estimated Teaching Time		Theory	Lab
Objective 5	List on the board and explain as required the four general rules to follow when handling transparent plastic materials.		
Objective 6	Discuss the appropriate work procedures for transparent plastics related to forming, cutting, and drilling. Use Transparency Master #3, Technical Information Supplement #4, and Instructional Supplements #2 and #3. Give a demonstration on forming, cutting (use both the circular-type saw and the band saw), and drilling (drill a shallow, medium, and deep hole); demonstrate what occurs when cutting and drilling are not done properly.		
Objective 7	Explain the methods which are used to cement plastics. Use Transparency Master #4. Demonstrate the soak method. **WARNING** ***Airframe Section*, EA-ITP-AB, specifies ethylene dichloride as the proper solvent for use in cementing acrylics. This solvent has been found to be hazardous (carcinogenic). Hazards associated with methylene chloride are stated in the Rohm and Haas booklet, *Plexiglass Design and Fabrication*, PL-7N, and applicable safety data sheets.**		
Objective 8	Use Technical Information Supplement #5 to discuss safety rules which apply to working with plastic and plastic adhesives.		
Objective 9	Discuss Project Guide #1 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. Have students complete the project. Review the project in class after all students have completed. (NOTE: The plastic formed in this project will be used for Project Guides #2-#4.)		
Objective 10	Explain why and how acrylic plastic cemented joints are cured. Have students complete Workbook Supplement #3.		

Estimated Teaching Time		Theory	Lab
Objective 11	Explain the general procedures and precautions used when repairing surface scratches in acrylic plastic. Use Instructional Supplement #4 and *Maintenance and Restoration of Aircraft Acrylic Transparencies with Micro-Mesh Cushioned Abrasives*. Show videotape, *Training Film for Maintenance and Restoration of Acrylic Transparencies with Micro-Mesh Cushioned Abrasives*.		
Objective 12	Discuss Project Guide #2 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. Have students complete the project. Review the project in class after all students have completed.		
Objective 13	Discuss the care and maintenance of transparent plastics. Include in your discussion cleaning (emphasizing proper cleaning materials), polishing, and protective measures related to extreme heat and to maintenance procedures involving paints and solvents. Assign Instructional Supplement #5 as home reading material. As an experiment, you can have the class bring in small samples of cleaning compounds and polishing materials found around the house. Be sure to include spray-can type materials. Place these samples on small pieces of acrylic plastics, label them, and allow the pieces to remain in contact with the samples for approximately two weeks. After two weeks, clean the materials from the surface and inspect. Inspect these samples periodically during the remainder of the airframe course. Record any evidence of crazing.		
Objectives 14-15	Discuss Project Guides #3 and #4 with the class; review all pertinent safety rules and precautions, and demonstrate all procedures. Have students complete the projects. Review the projects in class after all students have completed.		

Estimated Teaching Time		Theory	Lab
Objective 16	Explain the defects that are commonly found in transparent plastics and the causes of the defects. Show examples of defects in plastics which have been in service. Have students review Technical Information Supplement #6.		
Objective 17	Explain the procedures and precautions related to the removal and installation of transparent plastic assemblies. Explain the reasons for these procedures and precautions. Show small examples of riveted, bolted, and screw-type assemblies. These examples will be more effective if they are sectioned. Use Technical Information Supplement #7. Have students complete EA-ITP-AW 1:III:13-14 and EA-ITP-ASG 8-9:55-67 as a review.		

INSTRUCTIONAL SUPPLEMENT #1 — Types, Classes, and Associated Characteristics of Transparent Plastic Materials

CLASSES	TYPES	CHARACTERISTICS
Cellulose Plastics	Thermoplastic	Oldest—pulp & cotton—mixed with acids, i.e. nitric and acetic (cellulose acetate) Poor weather resistance Sensitive to humidity
Synthetic	Thermoplastic Thermosetting	Derived from coal, air, water, urea, petroleum, ethylene, phenol, formaldehyde, etc. Products: Acrylic plastic, nylon, vinyl, styrene, etc. May be opaque, transparent, or translucent

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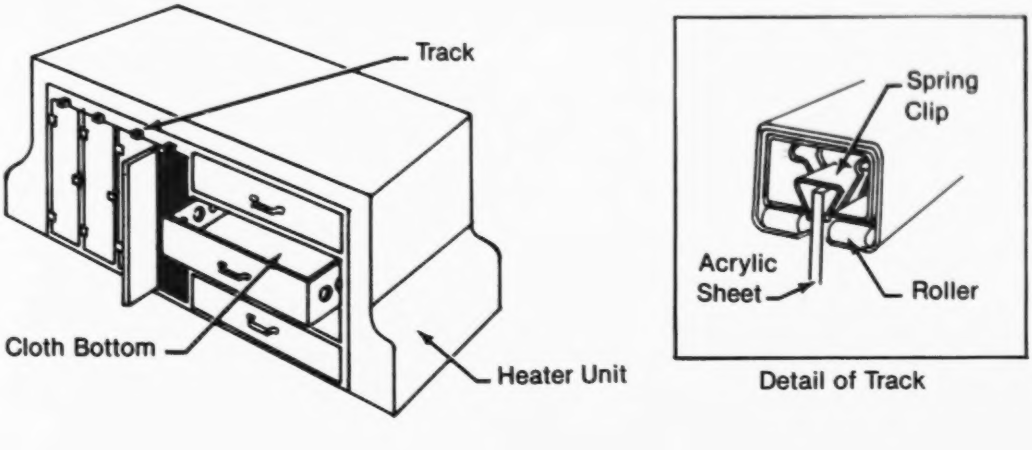
INSTRUCTIONAL SUPPLEMENT #2 — Plastic Forming and Annealing Ovens

Ovens are used for softening transparent plastic sheets prior to forming. A circulating air oven is preferable. A fan or other means of forced circulation should be employed to maintain as uniform a temperature gradient as possible throughout the oven. The oven should be capable of operating over a range of 49°C to 190°C (120°F to 374°F). For uniform heating it is best to hang the sheets of plastic vertically. Vertical support can be accomplished by an overhead monorail mounted in the roof of the oven, and equipped with a spring channel or a series of clips for grasping the plastic sheet. (See Figure A.) For small pieces which are inconvenient to handle, and for pieces cut with insufficient trim to which the clips or channels can be clamped, shelves or drawers must be provided. Shelves, covered with soft felt or flannel, should be of open-work construction to allow maximum circulation of air around the sheet to assure uniform heating. The air distribution should be uniform over the entire surface. Such an arrangement necessitates careful filtration of any fresh air which is admitted to the oven. In an emergency any available oven such as a kitchen baking oven may be used. White cotton gloves should be worn for handling the unmasked sheeting. Ovens are also used for annealing plastic enclosures prior to and after cementing and after machining or fabrication.

FIGURE A: Suggested forming oven layout



Detail of Track

Other less desirable means may be employed for heating transparent plastic prior to forming. For example, infrared lamps (Type R-40) may be used. They are usually arranged on 7- to 8-inch centers in a bank sufficiently large to cover the maximum size sheet involved. The sheeting should be placed approximately 18 inches from the face of the lamps to secure even distribution of the radiant heat. In general, any method other than oven heating is undesirable and should be used only in emergencies.

(NOTE: DO NOT use hot water or direct steam to heat transparent plastic because the plastic may become milky or cloudy.)

Source: United States Air Force.

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INSTRUCTIONAL SUPPLEMENT #3 — Types of Saws

Circular Saws. Circular saws for cutting transparent plastic should be hollow ground or have set or swage teeth to prevent binding. To obtain a smooth edge, the teeth should be *side dressed* on the machine after setting and sharpening. The plastic should be fed slowly enough to prevent overheating. The feed should not be forced, but will vary with the thickness of the stock being cut, the type of blade used, the speed and sharpness of the blade, and the power available. Moderate smoking and smearing at the edge is an indication of too rapid feed. A good practice for obtaining smooth edges at the exit end of the cut is to slow down the rate of feeding as the saw blade leaves the cut. (See Table A.)

TABLE A: Type of circular saw blade vs. thickness of plastic sheet

Thickness to be cut	Blade thickness	Teeth per inch	Type of blade
0.040 to .080 inch	1/16 to 3/32 inch	8 to 14	Hollow ground
0.100 to .150 inch	3/32 to 1/8 inch	6 to 8	Hollow ground
0.187 to .375 inch	3/32 to 1/8 inch	5 to 6	Spring set
0.438 to .750 inch	1/8 inch	3 to 4	Spring set or swaged
1.000 to 4.000 inch	1/8 to 5/32 inch	3 to 4	Spring set, swaged or cemented carbide

Band Saws. Where flat sheets are to be cut in curves or where formed parts are to be rough trimmed, band saws should be used. Metal cutting blades have been found best for plastics. (See Table B.)

TABLE B: Width of saw for various radii of cut standard dimensions

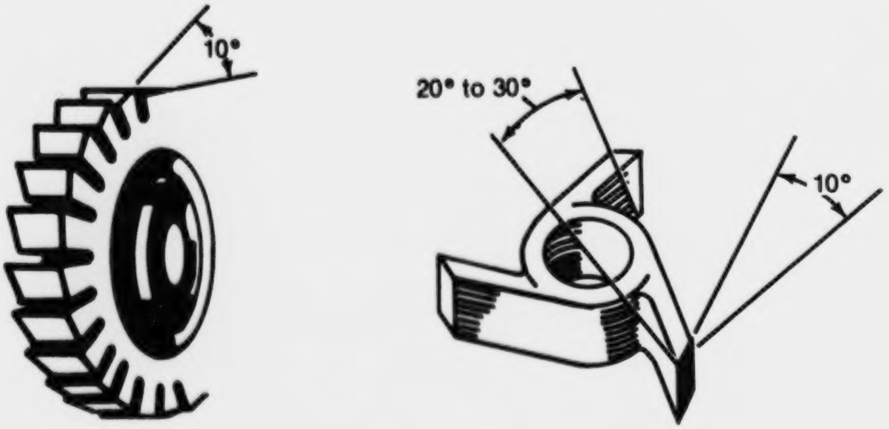
Width of saw	Points to inch	Thickness (Inches)	Thickness (Gage)	Minimum radius to be cut
3/16 inch	7	0.028	22	1/2 inch
1/4 inch	7	0.028	22	3/4 inch
3/8 inch	6	0.028	22	1 1/2 inch
1/2 inch	5	0.032	21	2 1/4 inch
5/8 inch	5	0.032	21	3 inch
3/4 inch	4	0.032	21	4 1/2 inch
1 inch	4	0.035	20	8 inch
1 1/4 inch	3	0.035	20	12 inch
1 1/2 inch	3	0.035	20	20 inch

Jigsaws. Jigsaws can be used for cutting closed holes in thin sheets of transparent plastic. They do not cut well through thick or multiple sheets. If it is necessary to use a jigsaw, the feed must be light and the teeth must be cleaned often.

Veneer Saws. Small circular saws are known as *veneer saws*. Veneer saws in portable tools are used mostly to trim large formed transparent plastic parts which are held in a trim jig or fixture.

Routing to Shape. For high speed portable routers, standard two-blade wood cutters give satisfactory results. On vertical spindle shapers, two-, three-, and even multiple-blade cutters may be used. In general, the greater the speed, the less the number of cutting edges required. Cutters up to three inches in diameter may be used without difficulty. Cutters should be kept sharp. They should be ground with a back clearance angle of about 10 degrees. The rake angle should be from 20 to 30 degrees for best results. (See Figure B.)

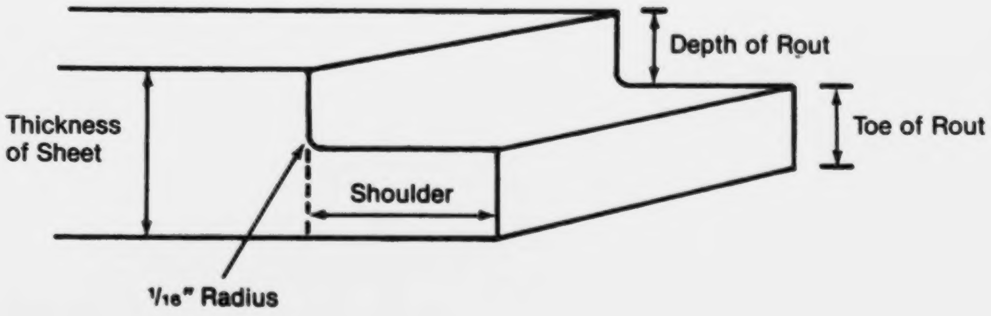
FIGURE B: Typical cutters for routers



Routing. For rabbet or stepped routs (See Figure C), the teeth of the cutter should be backed off on the underside to prevent drag and thus avoid burning. Wherever possible, the corners of routing cutters should be grounded to a $^{1}/_{16}$-inch radius so as to produce a fillet at the bottom of the rout. Where an edge of plastic bears on a router spindle collar as a guide during routing, a ball-bearing collar should be used or this collar or edge should be oiled to reduce friction and excess heating. It may be impossible to hold close tolerances in both the depth of the cut and the toe of the rout unless a subsequent, compensating machine operation is carried out after routing. Special cross-sections can be routed by using cutters ground to the desired shape. Rib shapes, for example, can be made by routing strips in much the same way that wood molding is produced.

INSTRUCTIONAL SUPPLEMENT #3

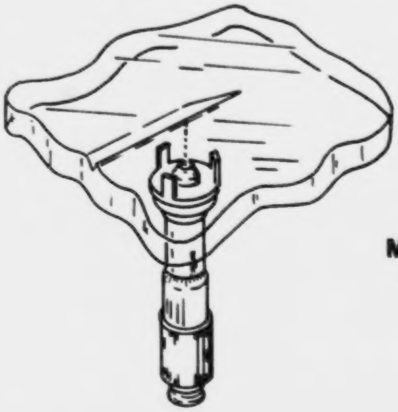
FIGURE C: Diagram of a step rout or rabbet

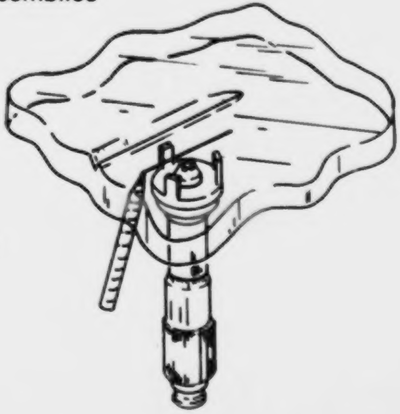


Scribing and Edge Sanding. This method of cutting is most generally employed on flat sections or two-dimensional, curved pieces. The sheet is first cut to approximate shape on a band saw, using a scribed line as a guide, and cutting approximately 1/16-inch oversize. Drum or belt sanders are most suitable for curved edges. Disc sanders work well when removing material from straight edges and outside curves. Air-driven grinders and small electric hand grinders are best fitted for sanding irregular shapes or larger pieces which are awkward to manipulate around a fixed machine.

Source: United States Air Force.

INSTRUCTIONAL SUPPLEMENT #4 — Measuring Thickness of Transparent Plastic Assemblies





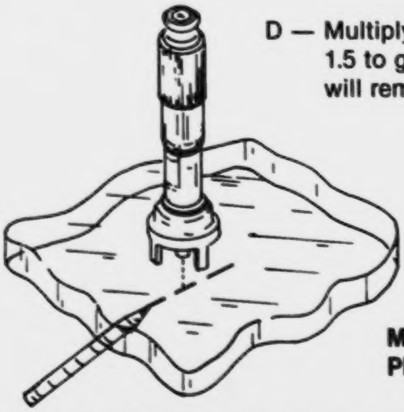
Measuring Thickness of Damaged Plexiglass

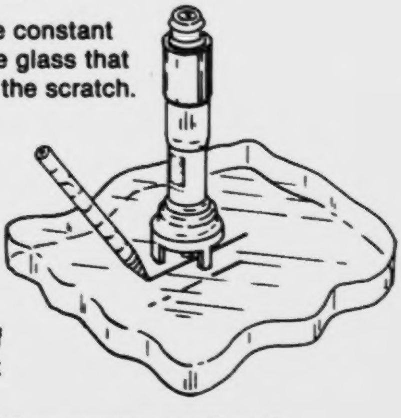
A — Focus on the apex of a scratch from the far side of the glass. Read the micrometer.

B — Make grease pencil mark on the near side, and adjust the micrometer to focus on this mark. Read the micrometer.

C — Subract reading "B" from reading "A".

D — Multiply this difference by the constant 1.5 to get the thickness of the glass that will remain after sanding out the scratch.





Measuring Thickness of Plexiglass After Rework

E — Read the micrometer when a grease pencil mark on the far side of the glass is in focus.

F — Make a grease pencil mark on the near side, and adjust the micrometer to focus on this mark. Read the micrometer.

G — Subtract reading "F" from reading "E".

H — Multiply this difference by the constant 1.5 to get the thickness of the glass.

Source: United States Air Force.

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INSTRUCTIONAL SUPPLEMENT #5

A Clear Outlook

by Robert Cupery
and Michael Guichard

Windows surround us, literally. They are a part of almost every structure built to move or shelter people—cars, boats, buildings, aircraft. But we virtually never notice them until we can't see through them. In fact, windows are so much a part of our lives we tend to think they are all alike.

When we start treating all windows the same way, however, we're asking for trouble. For one thing, not all windows are made of glass. With few exceptions, aircraft windows are formed from stretched acrylic, which provides a relatively inexpensive, tough, shatterproof transparency that is ideal for use on airplanes. What's more (and something many people forget), aircraft windows are primary structure, carrying all the loads the metal fuselage structure around them carries.

Acrylic aircraft transparencies deserve—actually demand—careful treatment and protection. This article will offer some guidelines. We'll divide our discussion into five major areas: cleaning and routine care, window removal, packing, window repairs and window installation.

Cleaning and Care

Windows, like everything else, change with age. Even with a conscientious maintenance program, you may still notice some discoloration—yellowing or milkiness. Such aging color cannot be removed without weakening the acrylic, since the color penetrates the entire thickness of the panel. So eventually you'll have to retire those old panels.

Nevertheless, you can extend the useful life of aircraft windows by following a few suggestions. *First, never use an ammonia-based glass cleaner on acrylic windows.* Ammonia may be great for glass, but it's hard on plastic. Even approved plastic cleaners in aerosol applicators should be avoided. While the cleaning agent is safe, the majority of aerosol chemicals will attack the acrylic.

To clean a panel properly, apply an approved plastic cleaning agent to the window. *With bare fingers*, gently massage the surface. You may feel tiny flakes of grit on your fingertips. Now take a very soft paper towel and, with a single sweeping motion, wipe across the window. As you turn over the towel to inspect it, you'll see that you've just manufactured a form of sandpaper, and rubbing that dirt into the window is worse than not cleaning it at all.

If, instead, you fold the towel over each time you wipe across the window, presenting a clean side of the towel to the surface on each pass, you will remove the abrasives and may safely buff the window. Sure, you'll use a few more paper towels and a bit more cleaner, but they cost a lot less than having to refinish your windows or purchasing new ones.

Removing Windows

Around the perimeter of each window, where it fits into the frame, is the *window radius*. Window designs vary, and some radii are thinner than the panel they surround, while others have a perspex ring that supports it. Whatever the design, be aware that the radius is a critical area. It's the area to which stress migrates across the face of the panel. You must remove windows with great care, protecting the radius from damage.

Never use razor blades or sharp metal objects to cut away sealant around the window. In our experience, about 60 percent of the windows that are removed and shipped for repair show signs of scoring and cutting in the radius area. Instead of razors or knives, use an acrylic scraper. Try this: Take a piece of plexiglas and grind a sharp edge on it, say, sharp enough to shave with. The scraper will cut sealant easily without damaging the acrylic.

Once you have removed the window from the aircraft (following the instructions from the technical manual), carefully remove all sealant from the radius. Inspect this area very closely. While the window is installed in the aircraft, you can't see what's happening in the radius. Sometimes, in an effort to install a window quickly or to block out intruding moisture, people experiment with unauthorized sealants—everything from silicone to water-based glue. Wrong! Unapproved sealants almost always contain chemicals that attack acrylic, causing that fine network of scratches calling *crazing*. As with metal structures, scratches or cracks in acrylic form stress risers that grow larger and eventually contribute to the failure of the whole window. In a pressurized cabin, that can be really exciting!

While you're inspecting the radius for crazing, look at the window edge. Is it chipped? Any chip becomes a point where stresses can congregate. Chips must be blended to relieve the stresses they encounter. If you need to know the allowable dimensions of edge chips, contact the window or airframe manufacturer.

Finally, examine the window frame for corrosion. Some DV (direct vision) window frames are magnesium. ***Never use zinc chromate as a primer on magnesium frames***; it accelerates corrosion. Instead, use an approved sand-blasting method to blast the frame down to bare metal. Then, using a micrometer, make certain that the frame wall is thicker than the allowable minimum thickness. Chemically treat the frame with an approved corrosion inhibitor, such as Dow 7. Now, you're ready to epoxy prime and top coat the frame.

Looking for Trouble

Now that you are accustomed to looking *at* windows instead of *through* them, you should be able to detect such damage as crazing. Normal crazing occurs in random patterns across the entire window surface; it resembles fine spider webs. These tiny scratches can grow with alarming speed. What you barely notice last year gets much worse in a few months. Then, within weeks, everyone notices the crazed windows, including the aircraft's passengers. Putting off the repair allows those hairline scratches to grow longer and deeper until repair becomes impossible. At this point, you must scrap the panel because the damage has extended beyond its minimum allowable thickness.

Another kind of crazing has a more predictable pattern—diagonal streaks extending downward along the exterior surface, like fine slivers of rain. This crazing is sometimes created by volcanic material hanging in the atmosphere. The material includes sulfuric acid droplets, created when sulfur dioxide mixes with atmospheric moisture. For example, in 1982 the Mexican volcano *El Chichon* belched over 13 megatons of sulfur dioxide into the atmosphere. It took 20 days for the massive cloud to encircle the earth, but it will take several more years for the particles to dissipate. As the airstream carries the acid across the acrylic surfaces of an aircraft, it etches the panels with fine lines. Although some manufacturers call the problem merely cosmetic, the scratches can grow and weaken the window. You have to treat the problem sooner or later to prevent the normal tendency for stresses to migrate to a vulnerable area, as mentioned previously.

Here's an easy way to detect any kind of crazing. Project a bright light (a 350-watt slide or movie projection lamp works well) onto the outside of the window at a 15- to 20-degree angle. Meanwhile, inside the aircraft, have an observer view the illuminated window at various angles. If the observer cannot see crazing at 90 degrees to the window (looking straight through) but notices it at the acute angles (15 to 20 degrees), then the crazing is probably about 0.010 inch deep. When the crazing is visible at all angles, it's at least 0.020 inch deep.

Suppose you've got crazed or scratched windows. Now what? You can rub out fine scratches using a number of products on the market. But beware. Removing acrylic materials from aircraft windows involves two problems: reducing panel thickness and creating local distortion.

Thickness. First, how thick are your aircraft window panels? The only reliable answer to that question comes from ultrasonic measurement across the entire panel. You just can't tell what you've got until you measure it. What is the panel's minimum allowable thickness? Since each manufacturer specifies a different minimum thickness, you have to consult your tech manuals or call the manufacturer.

Once you know both the panel thickness and its minimum allowable thickness, you can determine how much material, if any, you can safely remove to eliminate crazing and scratches. If you cannot determine the window thicknesses both before and after the repair, don't try to accomplish the repair yourself. You're dealing with a critical airframe structure.

Let's repeat: *Know the thickness of the panel or don't touch it.* New windows can be close to or at the minimum, while others are thick enough that they can be resurfaced several times. It's this criterion that any professional technician must be aware of.

Distortion. Remember what you saw when you looked in the funhouse mirrors—waviness and disproportion? Well, window distortion is anything but fun, and removing local scratches or rough spots in windows results in some visual distortion. To avoid distorting the panel, you have to remove the same amount of material across the whole panel.

Another cause of distortion results from excessive heat generated by rubbing and abrading. Abrasive-impregnated rubber wheels can produce local heating very quickly. At temperatures above 180°F the acrylic will thermally relax, growing in thickness and becoming weaker.

To understand this increase in thickness, you have to realize that, as aircraft window panels are manufactured, thick acrylic is heated, pulled, and formed into *stretched acrylic*, which is stronger than the unstretched material. When reheated, the material tends to return to its original thicker (and weaker) state, which no longer meets the strength values of the manufacturer.

So, just to be on the safe side, make sure the window panels do not undergo temperatures greater than 150° F.

Dirt pockets. If you notice as you polish the panel that it's actually becoming more scratched and crazed, you've probably run across dirt pockets. If you looked at those lines of volcanic crazing under magnification, you would find that within the lines are deposits of fine dust and grit. By polishing, you actually open these slender pockets and spill the contaminants onto the panel surface. Working that dirt into the panel can cause more scratches.

Chemical damage. When people decide to paint their aircraft or the window frames, they often do two things: They mask off the windows and they strip the undercoat of paint. The adhesives in some masking tapes attack acrylic and leave a perfectly straight line of crazing along the edges of the windows. Also, phosphoric acid, which is commonly used to wash a stripped aircraft prior to painting, will attack the anti-static coating used on many glass windowshields. Even the vapors of some of these chemicals are sufficiently toxic to burn into the anti-static coatings. Clearly, you must protect windows very carefully from stripper damage, or remove the windows from the aircraft before stripping.

Screws. Occasionally we see wash ports or other threaded holes in window panels with stress risers and cracks extending from them. This indicates that someone has overtightened a screw while installing it in the hole. Screws in acrylic holes should never be more than fingertight.

A special case of panel damage caused by screws can be seen in the British Aerospace (HS) 125-400 (and earlier) DV windows. If you notice a ¾-inch L-shaped scrape mark along the bottom center edge of the outer panel, chances are someone replaced the specified *flathead* mount screw on the "C" panel dessicator with a *roundhead* one. As you slide the DV window back to open it, the roundhead screw comes to rest on the panel, scraping it and marring the surface. Again, this L-shaped mark is a stress riser and should be removed.

Dessicators. Perhaps the most common problem in windows involves moisture ingression between the panels. Dessicators are supposed to keep that dead airspace between the panels moisture-free. However, if the dessicator crystals have become saturated (turning pale or white) or if the dessicator O-rings have deteriorated, moisture will enter the airspace. Once inside, the moisture forms droplets and rolls to the bottom of the window. Water then collects along the bottom-most sandwich of plies in the window frame. As the water freezes near the extremely cold temperatures of the exterior panel, it expands and pops the window seal.

By the time the maintenance department notices the problem of moisture ingression, it may have gone so far that "band-aiding" with fixes like blow-drying the window, pumping nitrogen through it, or water rinsing it won't help. Since the frame seal is broken, water will enter around the bottom edges. With progressive ingression and freezing, the water actually separates the panels. Panels can spring apart by as much as a half inch. And, of course, water also causes frame corrosion.

As you've heard so often before, an ounce of prevention is worth a pound of cure. Check your dessicators. Make sure the crystals are fresh (bright blue), and change them when they start to become pale. Make sure all dessicator connections and O-rings are tight and in good condition.

If you notice moisture inside the panels, you will have to remove the window and inspect it carefully for damage or corrosion. And have it overhauled using an approved sealant. Proven tooling fixtures are required to ensure proper panel-to-frame alignment. If not aligned, the assembly may not fit. Never grind the window or frame to make it fit.

Packing and Shipping

A common problem in packing windows for shipment is the use of adhesive and masking tape spread on the acrylic surface. We've already discussed damage due to adhesive chemicals. It is recommended that you cover windows for shipping and storage with a rubberized coating or a paper with a silicon- or rubber-based adhesive.

Suppose you have to replace a window and you pull one out of storage that has been there for a long time. As you peel off the "stick-em" paper in which it is wrapped, you notice some of the adhesive sticks to the window. Now, how do you remove the paper-adhesive residue from the window? Simple, just get a paper towel and saturate it in isopropyl alcohol or aliphatic naphtha (Specification TT-N-95, Type II; Mil-N-15178) and lay the towel on the window surface. After about 20 minutes, lift the towel off the window and gently remove the residue. Do not scrape!

If you ship any window out for repair, make sure the dessicator port can breathe. A blocked dessicator port can allow the panels to be pressurized, and under pressure the window seal can be broken. It's also a good idea to protect all tubes or projections from the window with bubble-pack or other foam coverings. Place the window in a plastic garbage bag (it won't scratch or adhere to the window) and put the bagged window into a heavy-duty cardboard or wood-frame box. Then install additional packing around the window to keep it from moving within the container.

Window Installation

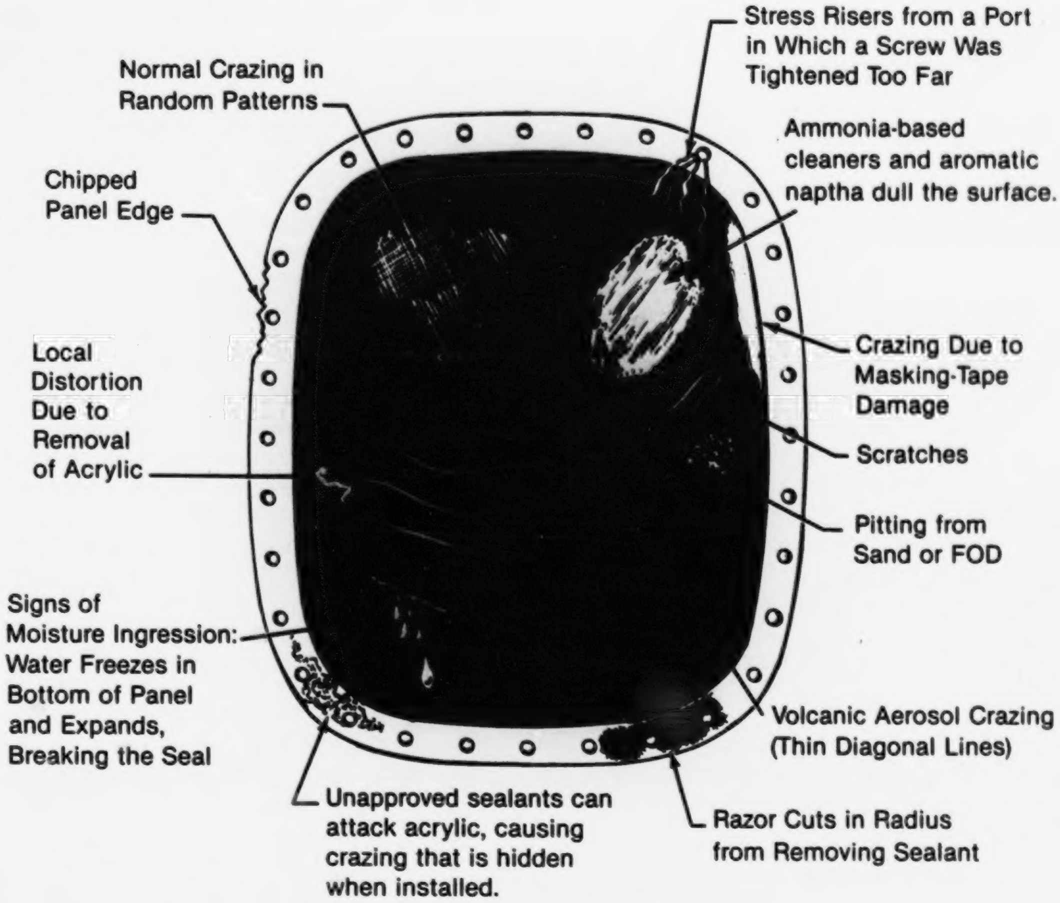
Again, make sure all passages, such as the dessicator ports, are free to breathe. Before installing the window, apply a manufacturer recommended release agent. As mentioned before, don't use aerosol applicators, because the aerosol chemicals might damage the acrylic. Finally, and let's emphasize it again, use the manufacturer-approved sealant. Look for the suffix "2" after the sealant designation. For example, "1422-B2" means that the sealant will set up in two hours. The B½ or the B1 will cure in a half hour and one hour, respectively.

Now, in order to get the sealant to cure quickly, chemical companies add accelerators to the sealant. Unfortunately, those accelerators—you guessed it—attack the acrylic. So try to avoid using a sealant that sets up in less than two hours. That may mean your aircraft will sit on the ground longer, but the windows will remain in better shape.

That objective—keeping aircraft windows clear and in good condition—is not particularly difficult once you understand the basics of window construction and maintenance. And avoid that most common mistake of all: looking through the window as if it weren't there. That's a luxury for the passengers.

INSTRUCTIONAL SUPPLEMENT #5

Window Woes


Normal Crazing in Random Patterns
Stress Risers from a Port in Which a Screw Was Tightened Too Far
Chipped Panel Edge
Ammonia-based cleaners and aromatic naptha dull the surface.
Local Distortion Due to Removal of Acrylic
Crazing Due to Masking-Tape Damage
Scratches
Pitting from Sand or FOD
Signs of Moisture Ingression: Water Freezes in Bottom of Panel and Expands, Breaking the Seal
Volcanic Aerosol Crazing (Thin Diagonal Lines)
Unapproved sealants can attack acrylic, causing crazing that is hidden when installed.
Razor Cuts in Radius from Removing Sealant

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TECHNICAL INFORMATION SUPPLEMENT #1 — Terms and Definitions

A. Thermoplastic resin — Resin material which will soften with the application of heat

(NOTE: Most aircraft windshields and side windows are made of this material.)

B. Acrylic — Glossy, transparent thermoplastic used for cast or molded parts such as aircraft windshields

C. Acetate — Cellulose acetate or any of its products

D. Cold-bending — Process of forming a single curvature in plastic material without raising the temperature of the material

E. Hot-forming — Working operations such as bending and drawing sheet and plate, forging, pressing, and heating, performed on metal heated to temperatures above room temperature

F. Forming — Process of shaping a part

G. Compound curve — Curvature of a metal surface in more than one plane

H. Die — Tool used to shape or form metal or other materials

I. Concave — Hollowed or rounded inward like the inside of a bowl

J. Surface tension — Condition that exists on the surface of a liquid because of molecular attraction

(NOTE: Surface tension produces an effect similar to a film stretched over a surface.)

K. Diffused — Not concentrated or localized; scattered

L. Monolithic — Formed or composed of material without joints or seams

M. Solvent — Liquid capable of dissolving another material

TECHNICAL INFORMATION SUPPLEMENT #2 — Transparent Plastics

Classes. There are a number of different classes of transparent plastics in use today. Of the various classes, the two that you will be working with are the cellulose plastics and synthetic resin plastics.

Cellulose plastics. Cellulose plastics are the oldest group, and include celluloid. Other plastics that fall into this class are acetate, nitrate, ethyl cellulose, and butyrate. Cellulose is made of wood pulp and cotton linters mixed with various acids, such as nitric and acetic acids. The plastic made of the acetic acids, and known as a transparent cellulose acetate, is used for some aircraft enclosures. This type is used mostly for the smaller liaison planes and older aircraft. The disadvantages for its use on aircraft concern its poor weather resistance and its sensitivity to change of humidity. Cellulose nitrate, which is one of the toughest of all thermoplastics, cannot be molded. Instead, it must be fabricated from preformed sheet, rod, or tube material.

Synthetic resin plastics. Synthetic resin plastics are the largest and most important group. Synthetic materials are derived from coal, air, water, urea, petroleum, ethylene, phenol, formaldehyde, etc. Products made from synthetic resins include acrylic plastic, nylon, vinyl, styrene, polyethylene, urea-formaldehyde, and others. Synthetic plastics are both of thermoplastic and thermosetting type; they can be molded by the various molding processes using heat and pressure or laminated under high and low pressure, and are produced in flat sheets, rods, tubes, and many other shapes in the extruded form. These synthetic plastics may be opaque, transparent, or translucent. Transparent plastic transmits both light and sight or image, while translucent transmits light only and no image. The opaque plastics transmit no light or image.

Types. Transparent plastics are grouped into two types—thermosetting and thermoplastic.

Thermosetting plastic. Thermosetting plastics cannot be reheated and reformed. In the manufacture of thermosetting plastics, fillers and fibers are added that result in a chemical change. And once the plastic sets, no reforming can be done. Once formed, thermosetting plastic products are not soluble or subject to attack by chemicals.

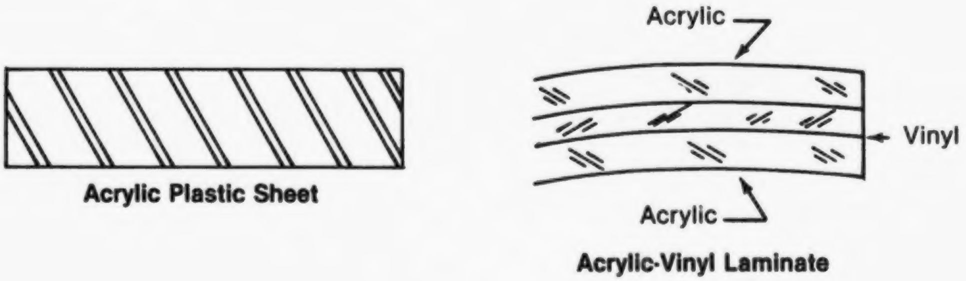
Thermoplastics. Thermoplastics may be reheated and reformed. In the manufacturing, no chemical change takes place. Thermoplastic materials have characteristics similar to those of sulphur and sealing wax. Sulphur is a hard, brittle material until it is exposed to heat. It then becomes soft and pliable; it has the consistency of a liquid if enough heat is applied. After cooling, sulphur again becomes hard and brittle. However, any time it is reheated, it can be cast or molded into any desired shape without damage to the material unless the specified heat ranges are exceeded.

TECHNICAL INFORMATION SUPPLEMENT #2

You work a great deal with acrylic plastics that are synthetic and thermoplastic. The major use of transparent acrylic plastics is for aircraft canopies, windows, blisters, domes, and similar transparent enclosures. Three types of transparent plastics commonly used are acrylic plastics (also known as acrylate or methacrylate base plastics), cellulose acetate base plastics, and laminated acrylic plastics. Laminated acrylic plastics are made by bonding acrylic plastic with a vinyl resin interlayer, as shown in Figure 1.

EXAMPLE:

FIGURE 1: Types of transparent acrylic plastic enclosure



Acrylic Plastic Sheet

Acrylic-Vinyl Laminate

Acrylic plastics are used for enclosures because of high transparent properties, strength-to-weight ratio, and forming ability. In addition to ease in fabrication and maintenance, plastics have other characteristics that make them better than glass for use in transparent enclosures. Plastics break in large dull-edged pieces, and they do not readily fatigue-crack from vibration. But on the other hand, although they are nonconductors of electricity, they become highly electrostatic when polished.

Source: United States Air Force.

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TECHNICAL INFORMATION SUPPLEMENT #3 — Specification Numbers For Transparent Acrylic Plastics

These are the most current specification numbers for transparent acrylic plastics used in common aircraft applications.

FED SPEC-L-391 MIL-P-21105B	Regular Acrylic (unshrunk)
MIL-P-5425B	Heat Resistant (preshrunk)
MIL-P-8184A	Crack Resistant (as manufactured)
MIL-P-25690	Highest Crack and Craze Resistant (8184 stretched)

The following have been cancelled:

- MIL-P-6886
- MIL-P-8257
- MIL-P-7524

TECHNICAL INFORMATION SUPPLEMENT #4 — Fabricating Processes for Acrylic Plastics

General Guidelines. The fabrication properties of acrylic plastics are generally compared to those of wood or soft metal. Good craftmanship, suitable equipment, and proper design are just as necessary to successful fabrication of acrylic parts as they are to good workmanship in wood. Light to medium woodworking equipment produces satisfactory results; however, heavy-duty machines, which are less apt to vibrate, are even better. General rules of machining apply; and once you get the "feel" of the plastic, you can do clean, accurate work. Keep your tools sharp and free from nicks and burrs. Since these plastics soften or become gummy when they are hot, keep frictional heat from building up or dissipate the heat by the application of a lubricant. Water or a mild soap solution makes a good lubricant for acrylic plastics and, if applied to a drill or saw, prevents burning or clogging. If the masking paper is still intact, be careful that contact of the lubricant with the masking paper is minimal. Moisture will cause a loss of strength in the masking paper, and removal is difficult. To prevent scratching during machining and forming operations, keep plastics covered either by applying masking tape or by leaving intact the masking paper applied by the manufacturer.

Cutting. Where extreme accuracy is not required, laying out the work may be accomplished by penciling and cutting lines directly on the masking paper. For close tolerances, however, it is advisable to scribe layout lines directly on the surface of the plastic. Use straightedges or layout templates according to the requirements of the job. If the masking paper is removed before scribing, replace it again to within 1/4 inch of the scribed markings before the piece is cut.

Layout templates may be of plastic sheeting to which suitable handles can be cemented. Round the sharp edges and smooth the rough spots. In the case of metal templates, it is good practice to cement thin flannel over the contact surfaces.

To cut plastic sheets, use ordinary hand, hack, band, circular, or jigsaws. Thin sheets may be cut by scribing a deep line, then breaking along the line. Hand and hack saw teeth should have very little set and should be fine enough so that at least two teeth are cutting at all times. To cut 1/8-inch stock, for example, you use a saw blade having a minimum of 16 teeth per inch. Band saws dissipate heat more readily than do circular saws. Accordingly, they operate at lower temperatures and are better suited for cutting thick plastic sheets. Fine teeth with no set produce a smooth cut if the work is fed slowly. If curves are to be cut, set is necessary even though narrow blades are used. Use jigsaws for cutting curves with small radii and band saws for larger curves. Adjust the blade guides as close to the work as possible so that control "weave" is kept to a minimum. Metal cutting blades have been found best for cutting plastics.

The feed for all types of hand and power saws cannot be accurately stated—it must be learned from experience—but in general, it is relatively slow. Moderate smoking and smearing at the edges are indications of too rapid a feed to too much pressure. A good practice for obtaining smooth edges at the exit end of a cut is to slow down the rate of feeding as the saw blade leaves the cut.

TECHNICAL INFORMATION SUPPLEMENT #4

Drilling. To drill holes use an end mill or an ordinary twist drill with the point ground. Use a moderate drill speed, feed slowly, and use light pressure to avoid "grabbing," especially as the drill breaks through on the other side of the piece of plastic. During the drilling operation, hold the work securely by clamps or other fixtures provided. Portable hand drills may be used in conjunction with special jigs; however, drill presses produce better drilling results.

As in the case of sawing, the feeding rate is a matter of experiment and judgment. Too fast a feed will cause chipping and strain cracks. Proper feed is indicated by smooth, continuous spiral chips or ribbons. Avoid overheating by decreasing the rate of feed as the depth of cut is increased.

Use drill lubricants because they aid in chip removal, dissipate heat, and improve the surface finish of the hole. The best lubricant for drilling acrylics is a thin, mild soap solution. It is possible to drill shallow holes satisfactorily without the use of a lubricant if you feed the stock slowly to avoid overheating. Lifting the drill from the work frequently to let it air-cool is good practice.

The best results can be obtained when drilling plastic if you remember the following:

a. Use twist drills with slow-spiral polished flutes. The flutes should be as wide as possible.

b. The twist drill should be carefully ground free of nicks and burrs which would affect the surface finish.

c. It is particularly important that the cutting edge of the twist drill be dubbed off to zero rake angle.

d. The length of the cutting edges (and hence the width of the chip) may be reduced by increasing the included angle of the twist drill.

Source: United States Air Force.

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TECHNICAL INFORMATION SUPPLEMENT #5 — General Safety Rules to Follow When Working with Plastic and Plastic Adhesives

CAUTION

Ensure that your facility is in compliance with local, state, and federal health, safety, and wiring codes.

1. Protect your lungs and eyes with the proper equipment when sanding, drilling, cutting, or performing any fabrication process
2. Make sure no open flame is present around solvents and adhesives
3. Make sure a properly maintained dry-chemical or CO_2 fire extinguisher is on hand or located nearby
4. Use nonflammable waste cans to dispose of flammable waste and soiled rags used in making repairs
5. Use only explosionproof lights and equipment in the repair area
6. Mix chemicals in accordance with manufacturer's instructions

   (NOTE: Improper mixing could result in an explosion.)
7. Work in a properly ventilated facility

TECHNICAL INFORMATION SUPPLEMENT #6 — Common Defects in Plastics

Crazing. Crazing is a pattern or area of tiny fissures or splits in the plastic, resembling the cracking of glaze in pottery or surface splits on weathered wood. Crazing having fissures of discernible width must be considered as cracks. The edges of crazing fissures cause undesirable highlights and reflections during night flying or during daylight flights especially when flying directly into the sun. Crazing is a warning that the material has been weakened physically by the presence of solvents or of concentrated and locked-in stresses that have been partially or completely relieved.

Crazing fissures are difficult to detect, since they are approximately perpendicular to the surface, very narrow, and usually not over 0.01 inch in depth. They can be best seen by moving the piece to be inspected under an overhanging light and looking at the surface of the plastic in front of a dark background. You can do this on an aircraft by using a light (flashlight or extension light) while looking on the outside surface and having a dark surface (cardboard or other black paper) on the underside. The minute fissures are both an optical and a mechanical defect because there is a separation of material.

If the crazing is in a random pattern, it can usually be ascribed to the action of solvents or solvent vapors. If the crazing is approximately parallel, the usual cause is a directional stress set up by cold-forming, excessive loading, improper installation, improper machining, or a combination of these. Once a part has crazed, neither the optical nor the mechanical defect can be removed. Consequently, the preventive measures are as follows:

a. Forming at sufficiently high temperature
b. Proper control of sawing, drilling, milling, routing, sanding, polishing, and other machining operations
c. Care in application of an approved cement
d. Careful installation in an approved manner
e. Use of approved cleaners only
f. Keeping acrylic parts away from solvents or solvent forms
g. Proper annealing of fabricated parts is the most effective single preventive measure against crazing

Scattered areas of light crazing are allowable in the canopy, windows, and other enclosures. They must be within the established optical requirements for the individual aircraft and never in an area that would impair vision.

TECHNICAL INFORMATION SUPPLEMENT #6

Distortion. Visual distortion is a visual imperfection in acrylic caused by the use of harmful cleaning materials or chemical vapors, improper cleaning practices, excessive heat or accumulation of surface damage through use. Distortion can also be caused by improper restoration (polishing) methods and/or materials used during attempts to repair damages, such as scratches, pits, and chipping. A critical examination should be made to detect visual distortion after the completion of a scratch removal operation.

Excellent lighting is imperative to recognize distortion, and bright sunlight should be used when possible. A check for distortion of acrylic plastic panels may be made by viewing horizontal and vertical lines through the panel at a distance of at least 30 feet from the panel. A grid manufactured for this purpose or the crossed frame of a window, will readily detect distortion in any direction. If the plastic panel has been removed, place it on a table and view the grid while simulating the position and movements of a pilot in the aircraft. The horizontal and vertical lines should retain their shape and position during all movements. A straight object should not curve or break pattern.

For several reasons, distortion in plastic may occur. A deep scratch, chip or pit, if not completely removed, will cause severe distortion in one location. If the distortion is localized and severe, it is probably due to a surface defect or to not removing enough plastic to blend a damaged area during a restoration attempt. Surface distortion takes the form of many very slight lines, even causing visual imperfections as objectionable as one severe line or spot of distortion. Surface distortion can result from manufacturing defects, minute scratches, improper handling and cleaning methods, or abrasive marks from an incomplete restoration attempt.

Your inspection of plastic assemblies requires checking for scratches, nicks (chipping), cracks, bubbles, delamination, fractures, crazing, and optical distortion. You visually inspect to determine if the assembly meets surface and optical requirements as outlined in the applicable service manual. The acceptable imperfection limits are given for windshields, side panels, canopies, etc. After reworking the assemblies or parts, inspect them for optical distortion, for thickness, and for compliance with the applicable service manual. You must also exercise good judgment when you inspect.

Mechanical Defects. Scratches are the most common defects in plastics. The length, depth, number of them in a given area, and location determine whether to replace the enclosure or plastic panel. Scratches are acceptable if they can be sanded or buffed out without reducing the panel thickness to less than prescribed (for visual concerns) by the applicable service manual. Nicks (chipping) are similar to scratches; these may be removed by sanding. However, this is not done if the removal of the material reduces the panel thickness to less than prescribed by the applicable technical order, or if the removal impairs vision.

Cracks and fractures are not acceptable in plastic enclosures. However, a temporary repair for a crack is given in Project Guide #3. Use this repair only under extreme emergency conditions. Surface imperfections (orange peel, pits, pimples, and mark-off) caused by lint impression are acceptable, provided these conditions do not impair vision or cause localized distortion.

Source: United States Air Force

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TECHNICAL INFORMATION SUPPLEMENT #7 — Removal and Installation of Transparent Panels

There are a number of methods by which transparent panels can be installed in aircraft. The method chosen by the manufacturer depends on the position of the panel on the aircraft and design stresses. When installing a replacement panel, follow the method of mounting given by the manufacturer.

General Factors. Plastic panels are reasonably flexible; but if they are forced into a frame, high or unequal stresses may set up in certain areas of the panel. When acrylic plastics are subjected to excessive stresses, they are apt to craze. This lowers the transparency and strength of the panel. It is important, therefore, that plastics be mounted so that internal stresses are avoided or kept to a minimum. If the replacement does not fit loosely into the mounting, obtain or form a new replacement or heat and reform the panel. However, reformed panels are not placed in areas where clear vision is critically important; replace with a newly formed panel. It is not advisable to heat and reform areas, as local heating methods are likely to be only superficial and not thorough enough to reduce stress concentrations. Fitting and handling is done with masking material in place. On the edges where transparent materials will be covered by attachments, remove the masking material. Also, since transparent plastics are brittle at low temperatures, installation should be done at normal temperatures, if possible.

Removal Factors. During the removal of plastic assemblies, there may be several different lengths and material composition of screws to be removed. You will save yourself a lot of problems later if you separate the different types of screws as they are removed. An easy way to do this is to draw a diagram of the assembly on cardboard, denoting the location of each screw hole. As each screw is removed, install it in its respective location on the cardboard. During installation of the panel, reinstall each screw in the same hole from which it was removed.

When a complete canopy frame assembly is removed from the aircraft for canopy replacement, the frame assembly should be mounted in a holding fixture. This prevents the frame assembly from shifting when the canopy is removed. Alignment measurements should be taken prior to removing the canopy from the frame. After the new canopy is installed, repeat the same alignment measurements. Properly matching measurements indicate that the frame hasn't shifted during canopy installation. All plate nuts should be checked for proper operation while the canopy is removed.

Pre-Installation Factors. Before installing plastic into the retaining frames, the surfaces are cleaned with aliphatic naphtha, TT-N-95. Apply naphtha with a clean cheesecloth or a small paintbrush and wipe dry before evaporation can occur. Repeat cleaning until surface is free of residual film. Wipe surface dry with a clean cheesecloth or cloth. The surface is ready for you to apply tapes, adhesives, gaskets, sealants and seals. General procedures for removing sealants is to scrape existing material from the area with a sharp knifelike tool made of phenolic or hardwood compound, Turco 2822. Scrape off loosened sealant at short intervals and reapply stripping compound until all old sealant is removed. Remove stripping compound, using an approved solvent such as methyl ethyl ketone (MEK). Before sealing, reclean surface with aliphatic naptha and let dry. The surface must be dry before sealing.

Installation Factors. Acrylic plastics expand and contract approximately three times as much as the metal channel in which they are mounted; suitable allowances must be made and specific rules must be followed during the mounting procedure. Allowances for dimensional changes with temperatures must be made. Use the values shown in Table 1 as minimum clearances between frames and the plastics. If possible, avoid bolting or riveting through the plastic sheet. Channel and clamp mountings distribute stress of expansion evenly throughout the sheets. Therefore, such mountings should be used if possible. In Figure 2 are drawings of some mountings. Do not use bolt and rivet installations that go through the transparent plastic on pressurized aircraft. Where you encounter difficulty in rivet installation, substitute bolts when installing replacement panels, provided they meet the manufacturer's original strength requirements and the bolts do not interfere with adjoining equipment. In bolt installations, use collar spaces, shoulders, or stop nuts to prevent excessive tightening of the bolt. Whenever such devices are used by the aircraft manufacturer, retain them in replacement installations.

EXAMPLES:

TABLE 1: Allowances for differential expansion and contractions*

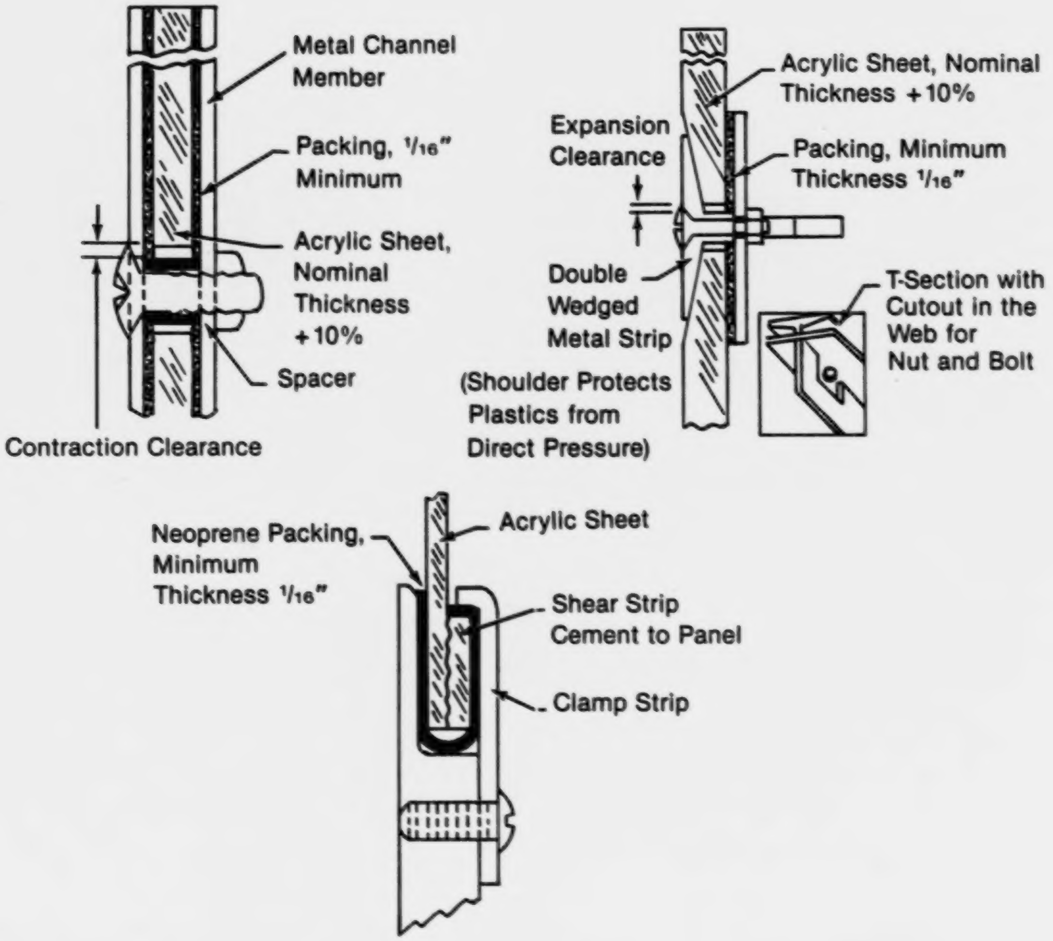
Dimension of Panel In Inches	Dimensional Allowance In Inches** ***	
	Required for Expansion From 25°C (77°F) to 70°C (158°F)	Required for Contraction From 25°C (77°) to -55°C (-67°F)
12	0.031	0.050
24	0.062	0.100
36	0.093	0.150
48	0.124	0.200
60	0.155	0.250
72	0.186	0.300

*Where the configuration of a curved part is such as to take up dimensional changes by change of contour, the allowances given may be reduced if it will not result in localized stress.

**For dimensions other than those given, use proportional clearance.

***Installations permitting linear change at both ends require half the listed clearances.

FIGURE 2: Methods of mounting plastic panels

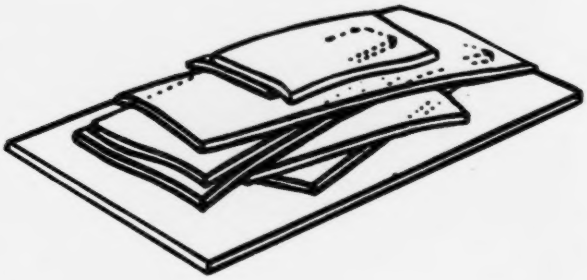

Metal Channel Member
Packing, 1/16" Minimum
Acrylic Sheet, Nominal Thickness +10%
Spacer
Contraction Clearance
Acrylic Sheet, Nominal Thickness +10%
Expansion Clearance
Packing, Minimum Thickness 1/16"
Double Wedged Metal Strip
(Shoulder Protects Plastics from Direct Pressure)
T-Section with Cutout in the Web for Nut and Bolt
Neoprene Packing, Minimum Thickness 1/16"
Acrylic Sheet
Shear Strip Cement to Panel
Clamp Strip

Screws torquing procedures should be in accordance with the applicable -3 TO instructions. Do not subject plastics assemblies to unnatural stresses during installation. Each screw must be torqued as specified to enable it to carry its portion of the load. If a plastic assembly is installed in a binding or twisting position and the screws are not torqued correctly, the plastic assembly may fail. One method of reducing unnatural stresses and at the same time, reduce hole misalignment, is to install screws diagonally back and forth across a plastic assembly in a criss-cross position.

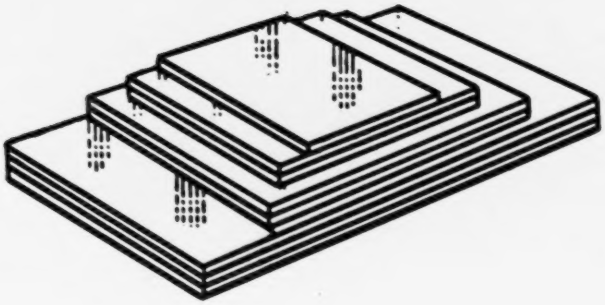
Source: United States Air Force.

Horizontal Storage of Plastic Sheets

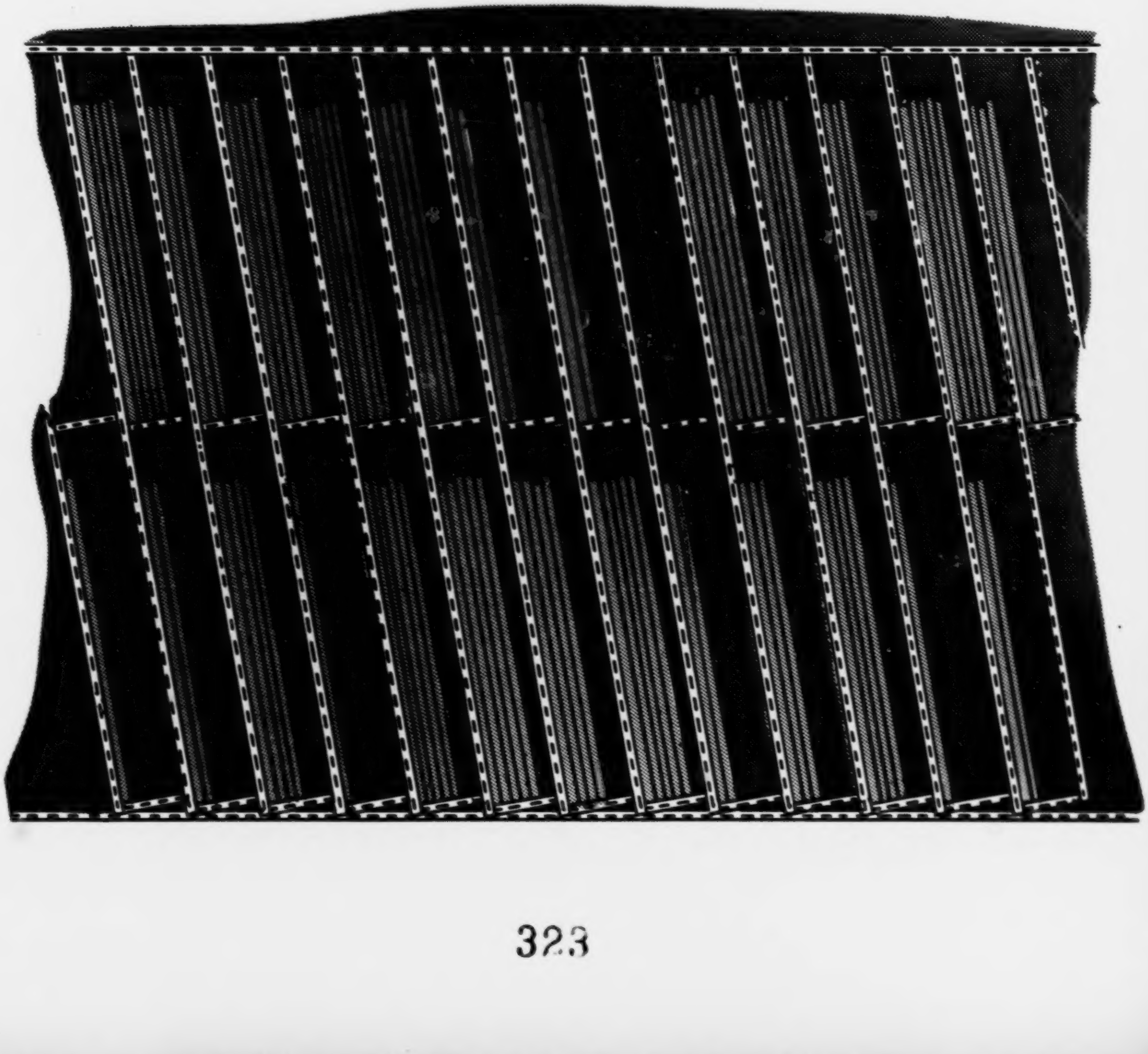
Incorrect



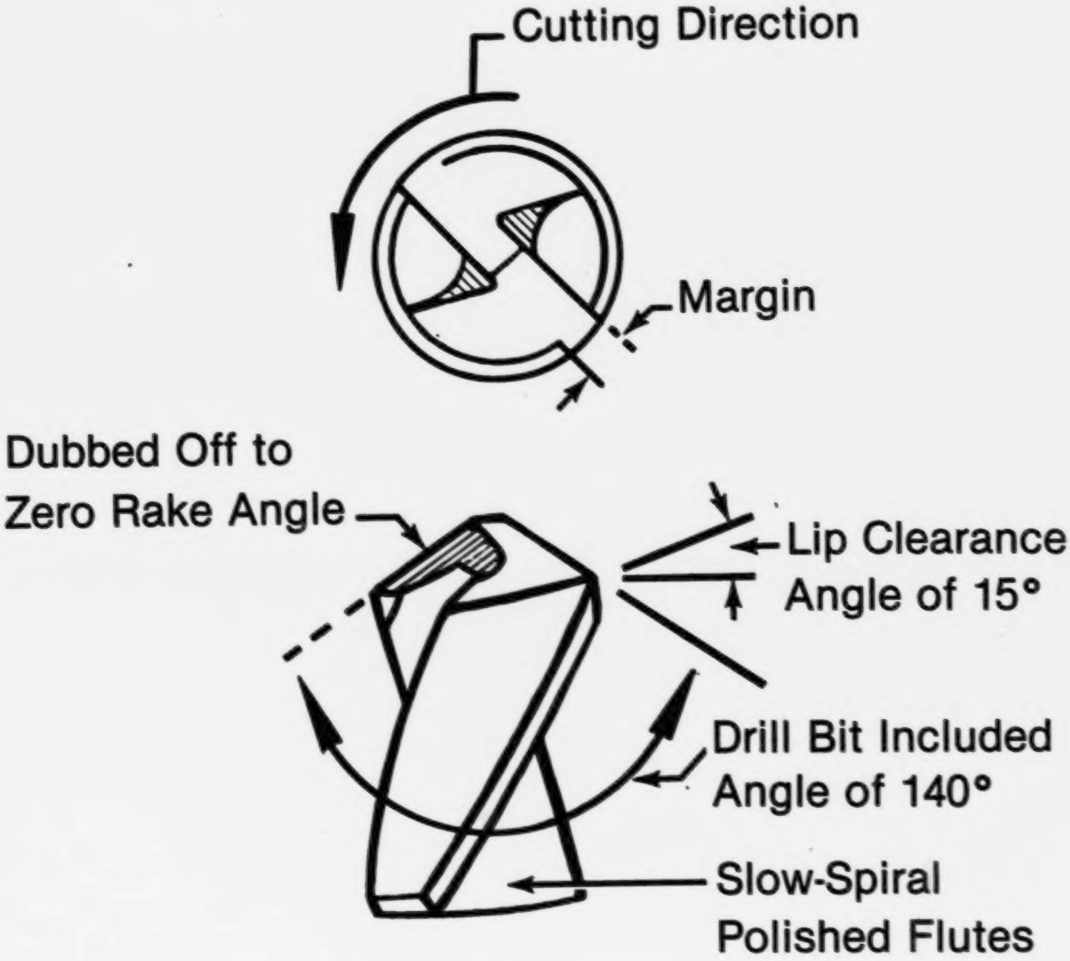
Correct



Vertical Storage of Plastic Sheets

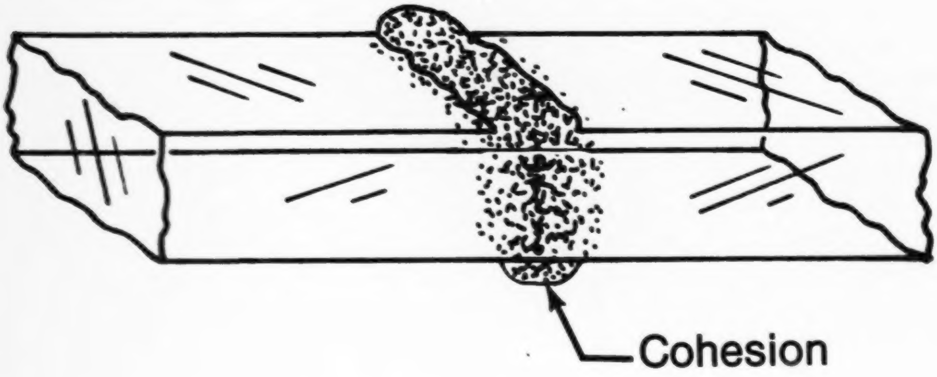


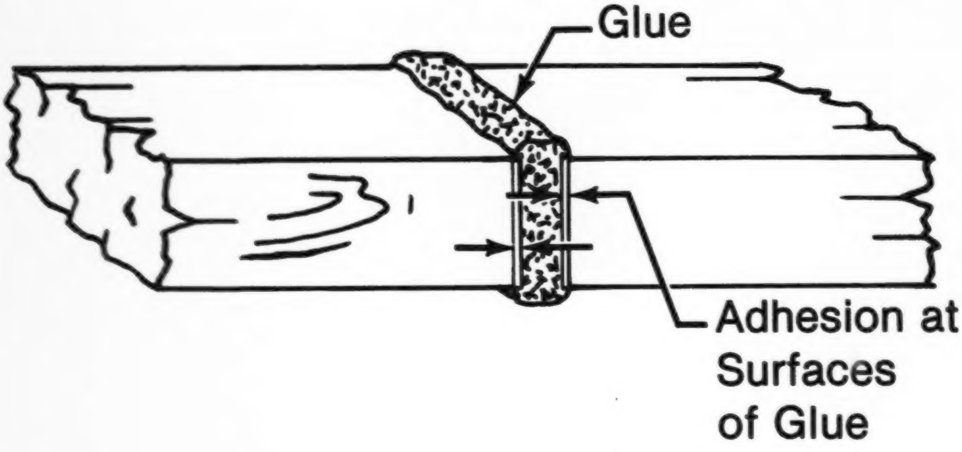
Recommended Twist Drill for Plastics


Cutting Direction
Margin
Dubbed Off to
Zero Rake Angle
Lip Clearance
Angle of 15°
Drill Bit Included
Angle of 140°
Slow-Spiral
Polished Flutes

Source: EA-AC 65-15A.

Distinction Between Cohesion and Adhesion




Glue
Adhesion at Surfaces of Glue

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WORKBOOK SUPPLEMENT #1 — Discuss Classifications and Types of Transparent Plastic Materials

The optical qualities of transparent material used in aircraft enclosures must be as good as those of the best quality plate glass. The quality must be of such that the flight crew can locate and identify other aircraft in flight and to assure the depth perception necessary to land the aircraft at high speeds. In addition to visibility, the aviation maintenance technician is concerned with strength, contour, and proper function of repaired units. The maintenance and repair of aircraft plastics can be greatly simplified if the aviation maintenance technician has a thorough knowledge of the properties of plastic materials.

A. List the four classifications of plastic resins.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

B. List the two types of plastics used in aviation.

1. ______________________________
2. ______________________________

C. The following statements characterize certain types and classes of plastics. Match the types and classes to the correct statements. Write the correct letters in the blanks. Answers may be used more than once.

_____1. This type can be reheated and reshaped more that once

_____2. Class of plastics derived from petroleum, phenol, etc.

_____3. This type retains its shape until it becomes useless from damage

_____4. Oldest class of plastics

_____5. Characteristics of this type when exposed to heat are the same as sealing wax

a. Synthetic

b. Cellulose

c. Thermoplastic

d. Thermosetting

______6. Class containing both thermoplastic and thermosetting types

______7. Once formed, this type is not soluble

______8. Fillers and fibers are added to this type resulting in a chemical change

______9. Class of plastics involving the use of nitric and acetic acids

a. Synthetic

b. Cellulose

c. Thermoplastic

d. Thermosetting

D. Identify the types of material for the following MIL specifications.

1. MIL-P-25690 — ____________________
2. MIL-P-5425B — ____________________
3. MIL-P-8184A — ____________________
4. MIL-P-21105B — ____________________

E. What is the color of cellulose acetate when viewed from the edge?

____

F. Describe the odors and flames which result from burning acrylic and cellulose acetate.

1. Acrylic — ____________________

____

2. Acetate — ____________________

____

G. What is the result when zinc chloride comes in contact with cellulose acetate and acrylic plastics?

____

____

H. What is the result when acetone comes in contact with cellulose acetate and acrylic plastics?

____

____

____

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WORKBOOK SUPPLEMENT #2 — Analyze Storage and Handling Procedures for Transparent Plastic Materials

The storage and handling of transparent plastic material requires special consideration due to its vulnerability to heat and surface damage. An aviation maintenance technician must have thorough knowledge of all procedures and precautions developed to ensure that transparent plastics retain all the qualities necessary for aviation applications.

A. Analyze the following circumstances and determine whether they are suitable or unsuitable for transparent plastic material. Write "suitable" or "unsuitable" in the blanks before the circumstances.

1. ____________ Plastic sheets are found to be stored in an area where the fumes from the paint shop can be easily detected

2. ____________ Plastic sheets are stored in bins at a 45-degree angle from the vertical

3. ____________ Masked plastic sheets are stored in bins at a 10-degree angle from the vertical in a room that has large windows on all sides

4. ____________ Plastic sheets are stored in a cool, dry location in a stack of 28 inches with the largest sheets on bottom and the smallest sheets on top, with no overhangs

5. ____________ Formed parts are found in an area where the temperature is approximately 110°F, and they are covered with cloth

B. Read through the circumstances in question A. In the following blanks write the number of each unsuitable circumstance, and explain why it is unsuitable.

____

____

____

____

____

____

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C. State the four general rules for handling transparent plastic materials.

1.

2.

3.

4.

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WORKBOOK SUPPLEMENT #3 — Discuss Appropriate Work Procedures for Transparent Plastics

Transparent plastic materials are superior to plate glass not only because of their high strength-to-weight ratio and enhanced safety due to the fact that they do not break into razor sharp shards but also because they are quite easily formed (the themoplastics), drilled, cut, and fabricated through the use of adhesives. The aviation maintenance technician must have knowledge and skill in these processes. Using the references listed in the Specific Objectives, answer the following questions.

A. Under what conditions may acrylic plastic be cold-bent?

____

____

B. What must be done before heating any transparent plastic material?

____

____

C. How can the best results be obtained when hot-forming acrylics?

____

____

D. What could happen if a part gets too hot during forming?

____

____

E. For uniform heating, what is the best method to use when installing the plastic in the heating equipment?

____

____

WORKBOOK SUPPLEMENT #3

F. When handling transparent plastics, how can finger marks be kept from marring the surface?

G. What is the most important factor to be considered relative to the form being used to shape plastic?

H. How can close control of size and shape be achieved by using the band saw?

I. How should a drill bit be modified to drill plastic?

J. Describe the soak method of cementing plastics.

WORKBOOK SUPPLEMENT #3

K. Describe the glue method of cementing plastics.

L. What happens to acrylic plastic when the solvent evaporates from a glued joint?

M. Why is a glued joint cured (heat treated) after the initial drying of the joint has occurred?

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ANSWERS TO WORKBOOK SUPPLEMENTS

Workbook Supplement #1

A.
1. Natural
2. Synthetic
3. Protein
4. Cellulose

B.
1. Thermoplastic
2. Thermosetting

C.
1. c
2. a
3. d
4. b
5. c
6. a
7. d
8. d
9. b

D.
1. Highest crack and craze resistant (8184 stretched)
2. Heat resistant (preshrunk)
3. Crack resistant (as manufactured)
4. Regular acrylic (unshrunk)

E. Yellowish tint

F.
1. Has a fairly pleasant odor, and burns with a steady, clear flame
2. Has repulsive odor, and burns with a sputtering flame and gives off dark smoke

G. Acetate-base plastic will turn milky; no effect on acrylic plastic

H. If the plastic is acrylic, it will turn white; if it is acetate, it will soften but will not change color

Workbook Supplement #2

A.
1. Unsuitable
2. Unsuitable
3. Unsuitable
4. Unsuitable
5. Suitable

B.
1. Plastic should never be stored in an area where there are fumes from solvents being used in the paint shop
2. Plastic sheets should be stored at an angle of approximately 10 degrees from the vertical
3. Masked plastic sheets should be protected from sunlight, which breaks down the adhesive and makes the paper difficult to remove from the plastic
4. Plastic sheets should never be stored in stacks higher than 18 inches

ANSWERS TO WORKBOOK SUPPLEMENTS

C. 1. Handle transparent plastic materials only with clean cotton gloves
  2. Never use harmful liquids as cleaning agents
  3. Follow rigidly the applicable instructions for fabrication, repair, installation, and maintenance
  4. Avoid operations which might tend to scratch or distort the plastic surface; be careful not to scratch the plastic with finger rings or other sharp objects

Workbook Supplement #3

A. If the material is thin and the radius around which it is bent is at least 180 times the thickness of the sheet

B. Clean and dry thoroughly

C. By using the temperatures recommended by the manufacturer

D. Bubbles could form on the surface

E. Hang the sheets vertically by grasping them by their edges with spring clips and suspending the clips in a rack

F. Wear cotton gloves

G. The form must be completely smooth

H. By cutting the material to within 1/16 inch of the scribed line, and sanding to the correct size with a drum or belt sander

I. Grind the drill with a greater included angle than you would use for soft metal (approximately 140 to 150 degrees); the rake angle should be zero

J. In the soaking method, one of the parts to be joined is soaked for about 10 minutes, or until a cushion forms. This cushion should be deep enough to take care of any discrepancies in the fit of the parts. After the cushion forms, press the wet surface against the opposite dry surface, and allow it to set for about half a minute. Then apply enough pressure to the joint to squeeze out any air bubbles and assure complete intermingling of the cushions

K. The glue method is used when it is not convenient to soak the edges of either of the pieces. Dissolve shavings of acrylic plastic in methylene chloride until you have a thick syrup or glue. Spread this glue on one of the surfaces, and assemble the parts. Allow the glue to set for a few seconds, then apply pressure to mingle the cushions

L. The acrylic shrinks

M. The heat treatment will cause the solvent contained in the joint to diffuse into a larger volume of plastic and become less concentrated; the material will then have more strength

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PROJECT GUIDE #1 — Cut and Form Acrylic Plastic

PURPOSE: To allow you to develop skill in handling, laying out, cutting, edge sanding, and forming acrylic plastic.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. Technical Information Supplement #4

EQUIPMENT AND TOOLS:

A. Oven (or approved alternative)

B. Band saw (same type of blade as required for metal)

C. Flannel-covered form (shaped similar to leading edge of wing)

D. Disc sander

E. Square (square head and blade with graduations recommended)

F. 6-inch rule

G. Respirator (approved for use with plastic)

H. Safety glasses

I. White cotton gloves

J. Safety cans (for naptha)

SUPPLIES AND MATERIALS:

A. Aliphatic naphtha TT-N-95, Type II

B. Soft, absorbent paper towels

C. Acrylic plastic (minimum size of 8" × 8")

D. Mild soap (suitable for plastics)

PROJECT GUIDE #1

PROCEDURE:

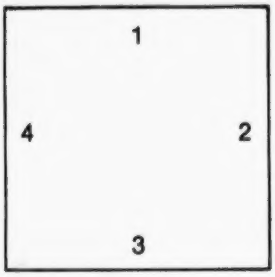
(NOTE: The protective masking paper should be left on the acrylic plastic while marking, cutting, or sanding is done.)

A. Select straight, smooth edge of plastic and designate it as Side 1

(NOTE: If the plastic does not have a straight edge, create one by cutting the plastic along a straight line as close as possible to one edge. Use Technical Information Supplement #4 for specific cutting information. Use appropriate respirator and safety glasses.)

B. Clockwise from Side 1, designate the remaining sides as Side 2, Side 3, and Side 4 (Figure 3)

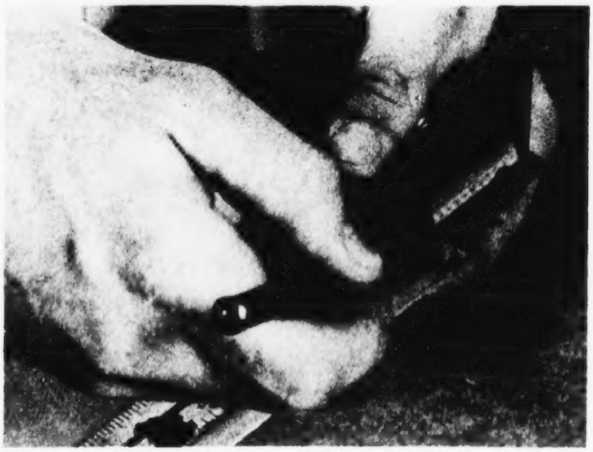
FIGURE 3



C. Measure in ¼ inch from any point on Side 2 using 6-inch rule, and mark location with pencil

D. Place square head on Side 1, extend blade along Side 2 through mark made in Step C, and draw pencil line along blade (Figure 4)

FIGURE 4



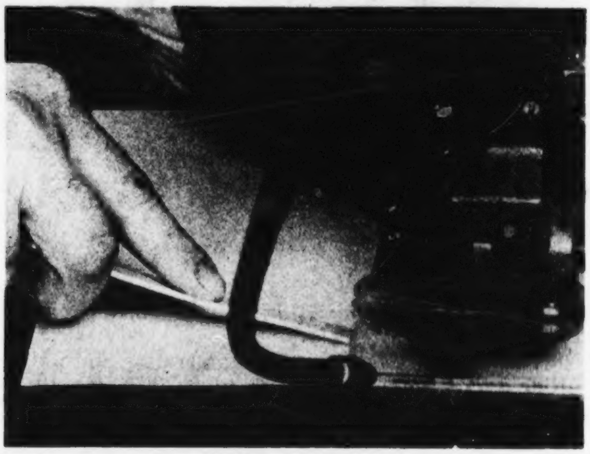
E. Use band saw to cut away section drawn in Step D (See Figure 5)

CAUTION

Use an approved respirator and wear safety glasses.

(NOTE: Place a piece of cardboard under plexiglass to keep from scratching surface. Sides 1 and 2 will be square, relative to each other, after cutting away this section. See Technical Information Supplement #4 for specific cutting information. If a band saw is not available, use another acceptable means. Saw should have a minimum of 10 teeth per inch.)

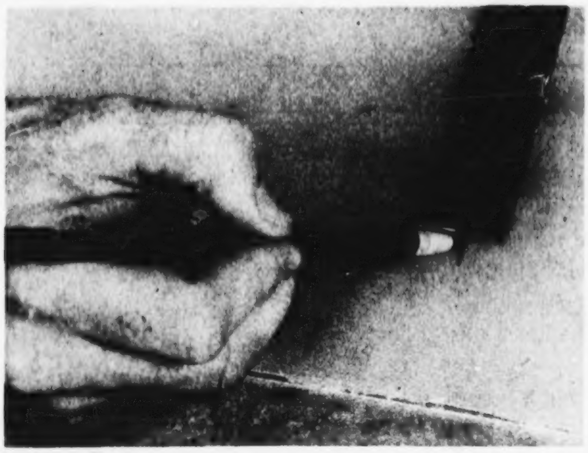
FIGURE 5



F. Set blade on square to extend 7 1/2 inches from head

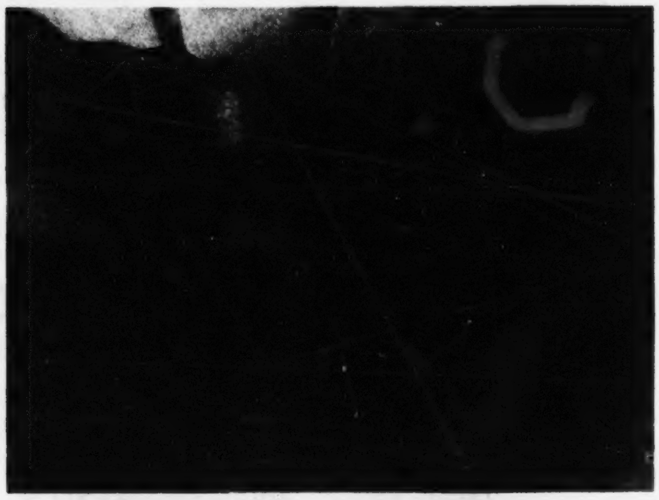
G. Use pencil and square to mark this length from Side 1 and Side 2 opposite Sides 3 and 4 respectively (Figure 6)

FIGURE 6



H. Lengthen blade on square and mark layout lines along Sides 3 and 4 (Figure 7)

FIGURE 7



I. Use band saw to cut away sections drawn in Step H

(NOTE: The plastic sheet should measure 7 1/2 inches on all sides, with all adjacent sides square, after cutting away these sections. Refer to Technical Information Supplement #4 for specific cutting procedure.)

> **CAUTION**
> Use an appropriate respirator and wear safety glasses.

J. Lay out a line 1/16 inch in from edge and parallel to Side 1

K. Using medium-grit paper, disc sand on Side 1 until layout line is removed; work carefully, and be careful not to overheat plastic

> **CAUTION**
> Respirator and safety glasses are required when sanding plastics.

L. Place square head against Side 1, and lay out a line 1/16 inch in from edge and parallel to Side 2

M. Carefully disc sand on Side 2 until layout line is removed

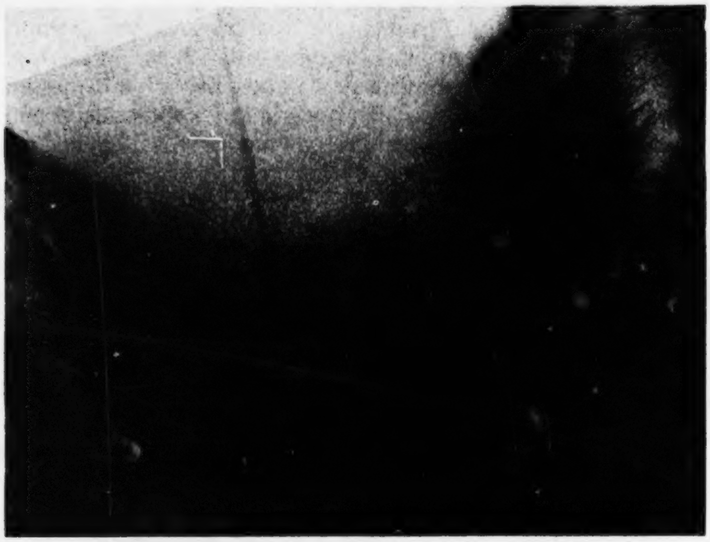
N. Repeat Steps L and M for Side 3 and Side 4

(NOTE: Use Side 2 to establish layout line for Side 3 and use Side 3 to establish layout line for Side 4. Be sure to do Side 3 before Side 4.)

O. Measure and check plastic for squareness (Figure 8)

(NOTE: The plastic sheet should measure 7 3/8 inches on all sides with all adjacent sides square.)

FIGURE 8



P. Remove protective masking paper from acrylic plastic

(NOTE: If masking paper adhesive has deteriorated through long or improper storage making removal of the paper difficult, moisten the paper with aliphatic naphtha. This will loosen the adhesive. Sheets so treated should be washed immediately with clear water.)

WARNING

Aliphatic naphtha, Specification TT-N-95, Type II, is highly volatile and flammable. Therefore, extreme care should be exercised when using this solvent. Use a fireproof-type can.

CAUTION

Do not use gasoline, alcohol, kerosene, benzene, xylene, ketones including acetone, carbon tetrachloride, fire extinguisher or de-icing fluids, lacquer thinners, aromatic hydro-carbon, ethers, glass-cleaning compounds or other unapproved solvents on transparent acrylic plastics to remove masking paper or other foreign material as these will soften and/or craze the plastic surface.

Q. Clean plastic thoroughly with mild soap and water

R. Dry sheet by blotting with soft, absorbent paper towels

S. Heat plastic in oven to temperature recommended by manufacturer

CAUTION

Allow sufficient time for the entire sheet to heat to the forming temperature. Thin material must be heated to a higher temperature than thick material because it cools more rapidly. Heating the plastic above the temperature range for the given grade of acrylic type plastic will cause bubbling on the surface of modified plastic material (Specification MIL-P-8184). In addition, overheating may impair some of the physical properties of the material before bubbling is apparent. When handling hot transparent plastic sheets, be careful to avoid fingermarks or otherwise damaging the soft surface. Wear white cotton gloves to handle plastic.

T. Put on cotton gloves

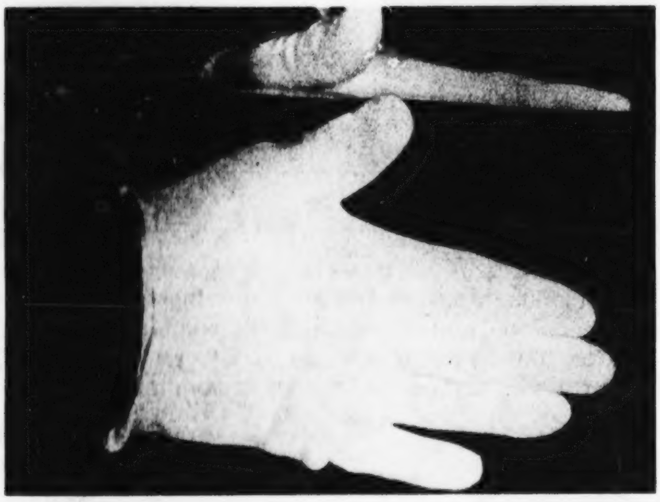
U. Remove plastic from oven

V. Form plastic

(NOTE: This process may take from ten minutes to half an hour, but do not force-cool plastic. Forms should be free of waviness and other variations in contour which might cause optical distortion in the formed part. The surface should be sanded smooth and covered with soft cloth, such as billiard felt outing flannel, flannelette, imitation chamois, or flocked or suede rubber sheeting. Be sure to wear white cotton gloves when handling plastic. Handle plastic by the edges as much as possible.)

1. Place plastic over form, carefully pressing it to form
2. Hold or clamp sheet in place until cool (Figure 9)

FIGURE 9



W. Turn off oven

X. Clean work area, and return tools and equipment to proper storage area

(NOTE: Retain plastic for Project Guides #2, #3, and #4.)

PROJECT GUIDE #2 — Repair Shallow Surface Scratches in Plastic

PURPOSE: To allow you to develop skill in the restoration of optical quality to acrylic plastic.

REFERENCE MANUALS:

A. EA-ITP-AB

B. AC 65-15A

C. *Maintenance and Restoration of Aircraft Acrylic Transparencies with Micro-Mesh Cushioned Abrasives*

EQUIPMENT AND TOOLS:

A. Micro-Surface Finishing Kit

B. Acrylic plastic formed in Project Guide #1

C. Appropriate personal safety devices and protective clothing

SUPPLIES AND MATERIALS:

A. Soft, absorbent cloth (100 percent cotton terry cloth or 100 percent cotton flannel)

B. Mild soap

PROCEDURE:

A. Read *Maintenance and Restoration of Aircraft Acrylic Transparencies with Micro-Mesh Cushioned Abrasives* thoroughly

B. Clean plastic according to booklet instructions

C. Have instructor place some minor scratches in one location on plastic

D. Restore plastic using Micro-Surface Finishing Kit and by following booklet instructions

E. Clean work area, and return tools and equipment to proper storage area

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PROJECT GUIDE #3 — Make Temporary Repair to Plastic

PURPOSE: To allow you to develop skill in drilling and making a temporary repair to plastic.

REFERENCE MANUAL: EA-ITP-AB

EQUIPMENT AND TOOLS:

A. Air-driven drill motor

B. #30 and #41 drill bits (these drills should have an included angle of 140 degrees to 150 degrees)

C. Diagonal cutting pliers

D. Duckbill pliers

E. 6-inch rule

F. Safety glasses

G. White cotton gloves

SUPPLIES AND MATERIALS:

A. Acrylic plastic used in Project Guides #1 and #2

B. 0.032 stainless steel safety wire (approximately 12 inches)

C. China marking pencil (grease pencil)

PROCEDURE:

A. Have instructor make a severe 2 ½-inch to 3-inch scratch on plastic to simulate crack

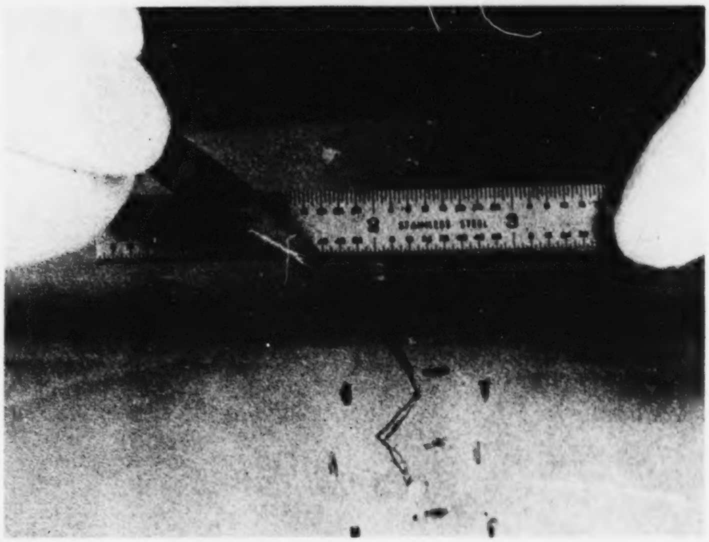
B. Stop-drill end of crack using #30 drill bit (See Figure 10)

(NOTE: This relieves stresses which are concentrated at the end of the crack.)

FIGURE 10

C. Lay out locations for holes to be drilled on both sides of crack using 6-inch rule and china marker, spacing holes ½ inch from edge of plastic and ½ inch from crack with ½ inch between all holes (Figure 11)

FIGURE 11

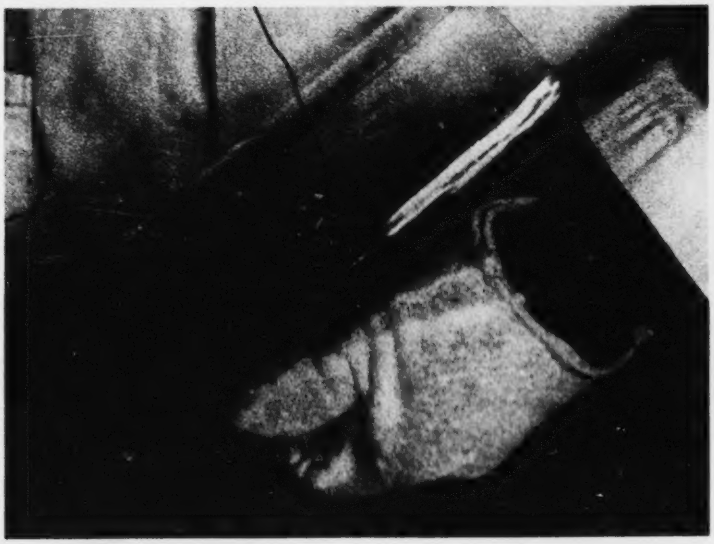


PROJECT GUIDE #3

D. Drill holes at these locations using #41 drill bit

E. Lace 0.032 safety wire through holes (Figure 12)

FIGURE 12



F. Have instructor check your work

G. Clean work area, and return tools and equipment to proper storage area

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PROJECT GUIDE #4 — Repair Transparent Plastic with a Surface Patch

WARNING

Never patch transparent plastics in a pressurized airframe.

PURPOSE: To allow you to develop skill in making a repair to plastic using a surface patch. This repair includes the processes of cutting and cementing.

REFERENCE MANUALS: AC 43.13-1A&2A

EQUIPMENT AND TOOLS:

A. Band saw (blade for metal with at least 10 teeth per inch)

B. Vixen file (regular cut)

C. File card

D. #30 drill bit

E. Air-driven drill motor

F. Safety glasses

G. Large spring clamp

H. 1" × 3" pieces of ¼-inch flannel-covered plywood blocks (or acceptable substitute)

I. Small metal mixing cup

J. Protective gloves

SUPPLIES AND MATERIALS:

A. Acrylic plastic used in Project Guides #1, #2, and #3

B. Acrylic plastic adhesive

C. Masking tape (3 MBD No. 221, CFM No. 670, Scotch No. 600)

(NOTE: These are available from 3M, St. Paul, Minnesota.)

D. Shop supply acrylic plastic

E. Shop supply wooden stir sticks

F. Mild soap (suitable for plastics)

PROJECT GUIDE #4

PROCEDURE:

A. Have instructor make a 2 1/2- to 3-inch scratch on plastic to simulate crack

B. Stop-drill the crack using #30 drill bit

C. Cut rectangular piece of plastic from shop supply of sufficient size to cover damage and extend 3/4 inch on each side of crack (Figure 13)

(NOTE: Acrylic patch may require forming if repair is to be made or curved portion of acrylic plastic.)

FIGURE 13

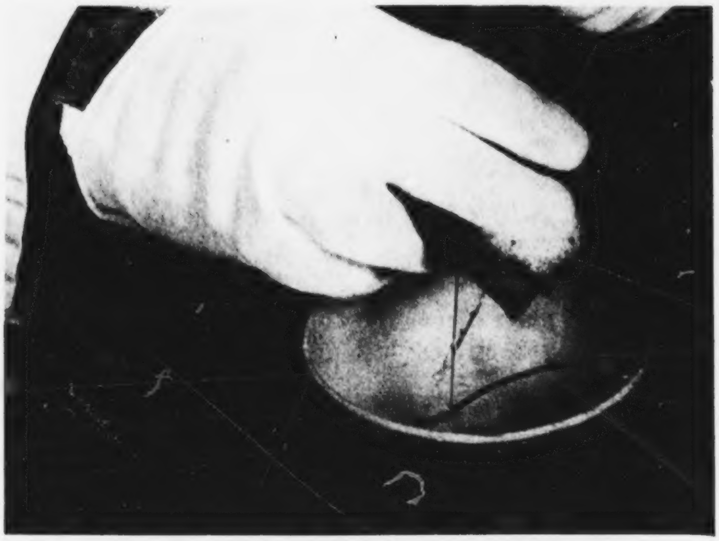
D. Bevel edges and round corners of plastic patch using vixen file (See Figure 14)

(NOTE: See AC 43.13-1A&2A, Figure 9.2. Protect the surfaces of the plastic patch during this step.)

FIGURE 14

E. Thoroughly clean plastic patch and surface to be patched with mild soap and water (Figure 15)

FIGURE 15



F. Mask area around where patch is to be installed and top surface of patch with masking tape (Figure 16)

FIGURE 16

G. Prepare adhesive as required by manufacturer's instructions

WARNING

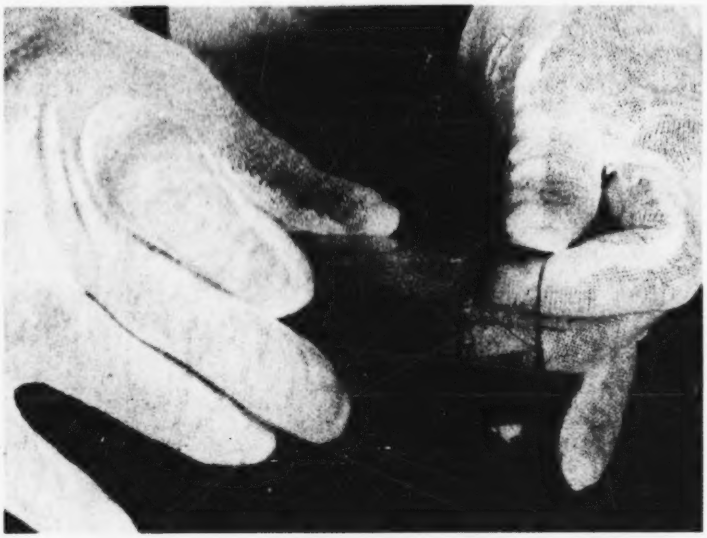
Methylene chloride is the main component of many acrylic adhesives, and it is toxic if its vapors are inhaled over a period of time. Adequate ventilation should be provided for personnel working with this cement, taking into consideration that methylene chloride vapor is heavier than air.

H. Spread viscous cement paste thickly on area where patch is to be applied (Figure 17)

FIGURE 17

I. Position patch on viscous cement paste, and do not apply any pressure (Figure 18)

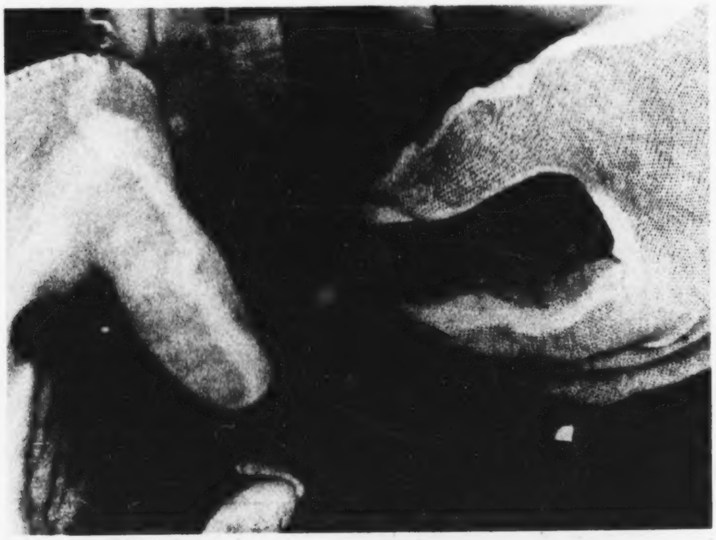
FIGURE 18



J. Allow cushion to form on both parts

K. Place patch under pressure using spring clamp and plywood blocks (Figure 19)

FIGURE 19



PROJECT GUIDE #4

L. Working carefully, use wooden stir stick to clean up bead of excess glue which squeezes from joint

M. Remove masking tape along joint when bead of glue no longer appears

N. Maintain pressure for a minimum of three hours

(NOTE: Allow patch to dry 24 to 36 hours before attempting to sand or polish.)

O. Remove spring clamp and blocks

P. Clean work area, and return tools and equipment to proper storage area

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THEORY TEST

1. Match terms related to transparent plastic materials to their correct definitions. Write the correct numbers in the blanks.

_____a. Process of shaping a part

_____b. Not concentrated or localized; scattered

_____c. Cellulose acetate or any of its products

_____d. Liquid capable of dissolving another material

_____e. Resin material which will soften with the application of heat

_____f. Formed or composed of material without joints or seams

_____g. Glossy, transparent thermoplastic used for cast or molded parts such as aircraft windshields

_____h. Tool used to shape or form metal or other materials

_____i. Process of forming a single curvature in plastic material without raising the temperature of the material

_____j. Condition that exists on the surface of a liquid because of molecular attraction

_____k. Working operations such as bending and drawing sheet and plate, forging, pressing, and heating, performed on metal heated to temperatures above room temperature

_____l. Hollowed or rounded inward like the inside of a bowl

_____m. Curvature of a metal surface in more than one plane

1. Compound curve
2. Surface tension
3. Solvent
4. Acetate
5. Forming
6. Concave
7. Monolithic
8. Thermoplastic resin
9. Hot-forming
10. Diffused
11. Acrylic
12. Die
13. Cold-bending

THEORY TEST

2. The following statements characterize types and classes of transparent plastics. Following each statement, specify the type or class of plastic to which the statement is referring.

   a. Class of plastic involving the use of nitric and acetic acids

   ____

   b. Class of plastic derived from ethylene, phenol, etc.

   ____

   c. Oldest class of plastics

   ____

   d. Class of plastic which is both thermoplastic and thermosetting type

   ____

   e. When heated, this type of plastic becomes soft and pliable

   ____

   f. Type of plastic that has characteristics similar to those of sulphur and sealing wax

   ____

   g. Type of plastic that can be reheated and reshaped more than once

   ____

   h. Type of plastic that retains its shape until it becomes useless from deterioration, damage, etc.

   ____

THEORY TEST

3. Plastics are identified by Military Specification Numbers and also by several simple tests which can be accomplished in the field. Identify transparent plastic materials by matching plastics to MIL specification numbers or the results of plastic identification tests. Write the correct numbers in the blanks. Some answers may be used more than once.

______a. MIL-P-21105B

______b. MIL-P-8184A

______c. MIL-P-5425B

______d. MIL-P-25690

______e. Has a yellowish tint when viewed from the edge

______f. Has a fairly pleasant odor when burned

______g. Turns white when acetone is applied

______h. Turns milky when zinc chloride is applied

______i. Burns with a sputtering flame and gives off dark smoke

1. Heat resistant (preshrunk)
2. Regular acrylic (unshrunk)
3. Crack resistant (as manufactured)
4. Highest crack and craze resistant (8184 stretched)
5. Acrylic plastics
6. Cellulose acetate plastics

4. Listed below are proper and improper procedures for storing transparent plastics. Select the proper procedures to employ when storing transparent plastics. Write a "P" in the blanks before the correct answers.

______a. Plastic sheets are stored best in very warm places

______b. Masked sheets should not be stored in direct sunlight

______c. Plastic should be stored in a cool, dry place away from any solvent fumes

______d. Plastic sheets should be stored in bins at an angle approximately 10 degrees from the vertical

______e. Store plastic sheets in horizontal position with the smallest sheets on the bottom

______f. Store formed sections in an area where the temperature does not exceed 120°F

THEORY TEST

5. State general rules to follow when handling transparent plastic materials.

   a. ______

   b. ______

   c. ______

   d. ______

6. There are many work procedures applicable to forming, cutting, and drilling transparent acrylic plastics. State the appropriate work procedures for transparent plastics when given data related to forming, cutting, and drilling by answering the following questions.

   a. If the masking tape on a plastic part was removed for scribing cutting lines, what must be done before actually cutting the part?

      ______

   b. When it is necessary to cold-form transparent plastic sheets, how is the correct bend radius to be used determined?

      ______

   c. How can close control of size and shape be achieved when using a band saw to cut acrylic plastic sheets?

      ______

d. What corrective action would you take when cutting plastic stock with a band saw if moderate smearing of the edges occurs?

e. When using a large-diameter drill to drill plexiglass sheets, what is the correct drill speed?

f. When drilling deep holes in a plastic structure, what must be done?

7. The two main ways of cementing acrylic plastics are the soak and glue methods. Describe these two methods of cementing acrylic plastics.

Soak

Glue

8. State general safety rules to follow when working with plastic and plastic adhesives.

a.

b.

c.

d.

e.

f.

g.

THEORY TEST

9. Cut and form acrylic plastic.

   (NOTE: Test question 9 is a project guide. It is an important part of this test. If it has not been completed, check with your instructor.)

10. Discuss the curing process of acrylic plastic cemented joints by answering the following questions.

    a. What is the purpose in curing (heat treating) acrylic plastic cemented joints?

    b. To what temperature should a cemented joint be heated in the curing process?

    c. How long should a cemented joint be kept at the appropriate temperature?

    d. What happens to a cemented joint in acrylic plastic as it cures?

11. State procedures and precautions to follow when repairing surface scratches in acrylic plastic when given the following related data.

    a. Scratches are found in an area where a repair may distort the pilot's vision.

b. A window on a pressurized aircraft has surface scratches; what factor must be taken into consideration?

c. Scratches are found in an area where they can be removed; describe briefly how they can be removed.

12. Repair shallow surface scratches in plastic.

(NOTE: Test question 12 is a project guide. It is an important part of this test. If it has not been completed, check with your instructor.)

13. Select true statements related to the care and maintenance of transparent plastics. Circle the letters before the correct answers.

a. If no scratches are visible after transparent plastic enclosure materials have been cleaned, their surfaces should be covered with a thin coat of wax

b. Two recommended solutions for routine removal of film and other operational soils from transparent plastic are a wetting agent, synthetic, non-ionic, conforming to MIL-Spec (MIL-D-16791) and a wetting agent, alkyl aryl sulfonate, 40 percent active

c. Cheesecloth is one of the best fabrics for cleaning transparent plastic

d. When an aircraft is parked where it is exposed to the sun and the surrounding temperatures are below 100°F, no special precautions are necessary

e. Sliding is the most preferred method for removing enclosure covers

f. Using aluminum foil is the most effective way to protect plastic from paint and other sprays which contain solvents

THEORY TEST

(NOTE: Test questions 14 and 15 are project guides. They are an important part of this test. If they have not been completed, check with your instructor.)

14. Make temporary repair to plastic.

15. Repair transparent plastic with a surface patch.

16. Defects which are detected in transparent plastics can sometimes be prevented from occurring again if the technician understands the causes of these defects. State the causes of specific defects found in transparent plastic.

    a. Defect — Crazing is in a random pattern

    Cause — ______________________________

    b. Defect — Crazing is approximately parallel

    Cause — ______________________________

    c. Defect — Severe distortion in one location

    Cause — ______________________________

    d. Defect — Distortion is localized and severe

    Cause — ______________________________

THEORY TEST

17. The process of installing a transparent plastic enclosure is critical. If certain procedures and precautions are not observed, the panel's service life will be drastically reduced, or the panel may fail in flight. State the reasons for the following specific procedures and precautions to follow when removing and replacing transparent plastic assemblies.

    a. Fitting and handling should be done with the masking material in place

    b. Plastic panels should never be forced into position in a frame

    c. Suitable allowances must be made between the frames and the plastic enclosures

    d. When rivets are used in the installation of acrylic plastics, oversize tube spacers or some other device is used

    e. Tighten each nut to a firm fit, then back off one full turn

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
INSPECT AND REPAIR TRANSPARENT PLASTIC MATERIALS
A201-D

ANSWERS TO THEORY TEST

1. a. 5
   b. 10
   c. 4
   d. 3
   e. 8
   f. 7
   g. 11
   h. 12
   i. 13
   j. 2
   k. 9
   l. 6
   m. 1

2. a. Cellulose plastics
   b. Synthetic resin plastics
   c. Cellulose plastics
   d. Synthetic resin plastics
   e. Thermoplastic
   f. Thermoplastic
   g. Thermoplastic
   h. Thermosetting

3. a. 2
   b. 3
   c. 1
   d. 4
   e. 6
   f. 5
   g. 5
   h. 6
   i. 6

4. b, c, d, f

5. a. Handle transparent plastic materials only with clean cotton gloves
   b. Never use harmful liquids as cleaning agents
   c. Follow rigidly the applicable instructions for fabrication, repair, installation, and maintenance
   d. Avoid operations with might tend to scratch or distort the plastic surface; be careful not to scratch the plastic with finger rings or other sharp objects

6. a. Replace the paper to within $^{1}/_{4}$ inch of the scribed markings before the piece is cut
   b. Transparent plastics may be cold-bent if the radius of curvature is at least 180 times the thickness of the sheet
   c. By cutting to within $^{1}/_{16}$ inch of the scribed line, and sanding to the correct size with a drum or belt sander
   d. Slow down the feed rate or change the saw blade
   e. Use a slow rotative speed
   f. Use slow-spiral twist drill with wide, polished flutes and an included angle of 140 degrees; also use a coolant

ANSWERS TO THEORY TEST

7. **Soak**

   In the soaking method, one of the parts to be joined is soaked for about 10 minutes, or until a cushion forms. This cushion should be deep enough to take care of any discrepancies in the fit of the parts. After the cushion forms, press the wet surface against the opposite dry surface, and allow it to set for about half a minute. Then apply enough pressure to the joint to squeeze out any air bubbles and assure complete intermingling of the cushions

   Glue

   The glue method is used when it is not convenient to soak the edges of either of the pieces. Dissolve shavings of acrylic plastic in methylene chloride until you have a thick syrup or glue. Spread this glue on one of the surfaces, and assemble the parts. Allow the glue to set for a few seconds, then apply pressure to mingle the cushions

8. a. Protect your lungs and eyes with the proper equipment when sanding, drilling, cutting, or performing any fabrication process
   b. Make sure no open flame is present around solvents and adhesives
   c. Make sure a properly maintained dry-chemical or CO_2 fire extinguisher is on hand or located nearby
   d. Use nonflammable waste cans to dispose of flammable waste and soiled rags used in making repairs
   e. Use only explosionproof lights and equipment in the repair area
   f. Mix chemicals in accordance with manufacturer's instructions
   g. Work in a properly ventilated facility

9. Performance skills evaluated to the satisfaction of the instructor

10. a. Curing is done so that the solvent contained in the cushion used to form the joint will be diffused into a larger volume of the plastic and become less concentrated; this will make the joint stronger
    b. 122°F (50°C)
    c. 48 hours
    d. The joint shrinks

11. a. No sanding should be done in this area
    b. The manufacturer will specify the maximum amount the window thickness can be reduced
    c. Use 320- or 400-grit abrasive paper wrapped around a felt or rubber pad. Using light pressure and a lubricant, polish the scratches out of the material. Use consecutively finer grit paper until all the repair marks are removed. Buff using rubbing compound to remove all traces of the sanding

12. Performance skills evaluated to the satisfaction of the instructor

ANSWERS TO THEORY TEST

13. a, b, d

14. Performance skills evaluated to the satisfaction of the instructor

15. Performance skills evaluated to the satisfaction of the instructor

16.
    a. Can usually be ascribed to the action of solvents or solvent vapors
    b. Can usually be ascribed to a directional stress set up by cold-forming, excessive loading, improper installation, improper machining, or a combination of these
    c. This can be caused by a deep scratch, chip, or pit if not completely removed
    d. Probably due to a surface defect or to not removing enough plastic to blend a damaged area during a restoration attempt

17.
    a. To prevent the damage to the surface of the plastic
    b. Forcing a plastic panel into a frame will set up stresses in the panel which will produce crazing
    c. This is done because plastics will expand and contract three times as much as metal
    d. This will protect the plastic from excessive tightening of the frame to the plastic
    e. To prevent stress on plastic

AIRFRAME

A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS

COURSE TEST

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIRS
COURSE TEST

Read the following questions and darken the circle in the column of the corresponding letter which indicates the correct answer on the answer sheet.

1. When balsa wood is used to replace a damaged honeycomb core, the plug should be cut so that

   a. The grain is parallel to the skin.
   b. It will be slightly compressed when the repair is completed.
   c. It is about 1/8" undersize to allow sufficient bonding material to be applied.
   d. The grain is perpendicular to the skin.

2. In a transition area bonded honeycomb panel repair, the circular shape repair should not exceed

   a. 2 inches in diameter.
   b. Twice the bay area thickness.
   c. Five times the flange area thickness.
   d. 5 inches in any direction.

3. Honeycomb core material used to replace damaged aluminum cores of honeycomb bonded structures is usually

   a. Titanium.
   b. Fiberglass.
   c. Stainless steel.
   d. Magnesium.

4. A typical repair used to retain 100 percent strength to a damaged area 1 inch in diameter of bonded honeycomb is

   a. A step-type metal facing patch.
   b. An overlap-type metal facing patch.
   c. A scarf-type facing patch.
   d. An overlap-type resin-glass facing patch.

5. A potted compound repair on honeycomb can usually be made on damages less than

   a. 3 inches in diameter.
   b. 2 inches in diameter.
   c. 4 inches in diameter.
   d. 1 inch in diameter.

COURSE TEST

6. When repairing puncture-type damage of a metal faced laminated honeycomb panel, the edges of the doubler should be tapered

   a. Two times the thickness of the metal.
   b. Five times the thickness of the metal.
   c. 100 times the thickness of the metal.
   d. To whatever is desired for appearance.

7. When making repairs to laminated honeycomb panels, microballoons are sometimes used to

   a. Speed up the curing process by allowing air to circulate around the molecules.
   b. Lower the density and provide greater flexibility.
   c. Serve as a blocking agent to prevent the uncured resin from entering the honeycomb.
   d. Slow down the curing process to allow a longer working time.

8. When inspecting a honeycomb structure using the metallic ring test, a clear metallic sound indicates

   a. Core damage.
   b. Facing and core sound.
   c. Facing damage.
   d. Facing and core separation.

9. What type inspection procedure should be used to check for water in the honeycomb of a composite structure?

   a. Shake the component and listen for water movement.
   b. Eddy current.
   c. Magnetic particle.
   d. Radiography.

10. The simplest test in checking for a delaminated area on a honeycomb structure would be

    a. The metallic ring test.
    b. X-ray.
    c. Ultrasonic.
    d. Zyglo.

11. Sandwich panels made of metal honeycomb construction are used in high-speed aircraft because this type construction

    a. Is lighter than single sheet skin of the same strength and is more corrosion resistant.
    b. May be repaired by gluing replacement skin to the inner core material with thermoplastic resin.
    c. Requires only self-tapping screws for the attachment of skin when repairing damaged areas.
    d. Has a high strength-to-weight ratio and greater stiffness than a single sheet.

COURSE TEST

12. What precaution should be taken to prevent corrosion inside a repaired metal honeycomb structure?

    a. Prime the repair with a corrosion inhibitor and seal from the atmosphere.
    b. Paint the outside area with several coats of exterior paint.
    c. Coat mating surfaces and all fasteners with thin oil.
    d. None. Honeycomb is usually made from a man-made or fibrous material which is not susceptible to corrosion.

13. One method of inspecting a laminated fiberglass structure that has been subjected to damage is to

    a. Strip the damage area of all paint and shine a strong light through the structure.
    b. Use dye penetrant inspection procedures, exposing the entire damage area to the penetrant solution.
    c. Use an eddy current probe on both sides of the damaged area.
    d. Use magnaflux inspection procedures for all areas where damage is suspected.

14. When inspecting a fiberglass panel using the "tapping" test procedure, a dull thud from the tapping tool indicates

    a. A solid inner core of the laminated panel.
    b. Separation of the laminates used in the lay-up.
    c. That the fiberglass resin is properly cured.
    d. That the panel is probably serviceable.

15. Damage evaluation charts for honeycomb structures of a large aircraft can be found in the applicable section of its

    a. Overhaul manual.
    b. Maintenance manual.
    c. Structural repair manual.
    d. Type data sheet.

16. When removing damage from one face sheet of a laminated honeycomb panel, it is important to avoid damaging the opposite face sheet. The most effective tool for removing a damaged area 1" diameter or less is

    a. A router and template.
    b. A hole saw of the proper size to remove all the damage.
    c. A rotary file.
    d. A pair of aviation snips for a left-hand cut.

COURSE TEST

17. Exposure of honeycomb structures to sonic vibrations usually cause

    a. Delaminations.
    b. Radiographic corrosion.
    c. Aerodynamic smoothness.
    d. Punctures.

18. When making repairs to fiberglass structures, cleaning of the area to be repaired is essential for a good bond. The final cleaning should be made using

    a. Lacquer thinner.
    b. Methyl-ethyl-ketone (MEK).
    c. Soap, water, and a scrub brush.
    d. A thixotropic agent.

19. Polyester resin is cured by which of the following processes?

    a. Applying external heat.
    b. Air cure.
    c. Adding a catalyst which joins the molecules.
    d. A combination of air drying and pressure application.

20. What is the purpose of a thixotropic agent used in plastic resins?

    a. Prolongs the curing process.
    b. Reduces the moisture content of resin.
    c. Adds flexibility to the resin.
    d. Thickens the resin to a paste-like consistency.

21. One of the main advantages of honeycomb structure is that it

    a. Is better able to withstand sonic vibration.
    b. Is relatively fireproof.
    c. Does not require inspections.
    d. Is very strong because it is heavy.

22. How can stress concentrations be eliminated when making scarf repairs in composite structures?

    a. Use a core filter of higher density than the original material.
    b. Mix the resin catalyst in such proportions that the cured resin will be somewhat flexible.
    c. Avoid abrupt changes in cross-sectional areas.
    d. Use square- or rectangular-shaped scarf patches.

23. What is the most effective method for determining if the proper ratio of resin-to-catalyst was used when making epoxy repairs?

    a. Make a pull test on the overlapping material.
    b. Test with a hardness tester in each square inch of new material.
    c. Mix enough epoxy to have a sample for testing after curing.
    d. Mixing ratios are not critical, therefore no evaluation of the materials used is necessary.

24. Superficial scars, scratches, surface abrasion or rain erosion on fiberglass laminates can generally be repaired by applying

    a. A piece of resin-impregnated glass fabric facing.
    b. A surface patch by means of epoxy resin cured for 1 hour with an infrared heat lamp.
    c. One or more coats of suitable resin (room-temperature catalyzed) to the surface.
    d. A sheet of cellophane over the abraded surface and one or more coats of resin cured with infrared heat lamps.

25. Fiberglass laminate damage not exceeding the first layer or ply can be repaired by

    a. Filling with a putty consisting of compatible resin and clean, short glass fibers.
    b. Placing a sheetmetal plate over the damaged area and securing with self-tapping screws.
    c. Sanding the damaged area until aerodynamic smoothness is obtained.
    d. Trimming the rough edges and sealing with paint.

26. Fiberglass laminate damage that extends completely through one facing and into the core

    a. Cannot be repaired.
    b. Requires the replacement of the damaged core and facing.
    c. Can be repaired by using a typical metal facing patch.
    d. Requires a plywood reinforcing plate installed with self-tapping screws over the damaged area.

27. Fiberglass damage that extends completely through a laminate sandwich structure

    a. May be repaired.
    b. May not be repaired.
    c. Must be filled with resin to eliminate dangerous stress concentrations.
    d. May be filled with putty which is compatible with resin.

28. The coefficient of expansion of most plastic enclosure materials is

    a. Greater than both steel and aluminum.
    b. Greater than steel but less than aluminum.
    c. Less than either steel or aluminum.
    d. Approximately the same as aluminum.

29. Which of the following is considered good practice concerning the installation of acrylic plastics?

    a. When nuts and bolts are used, the plastic should be installed hot and tightened to a firm fit before the plastic cools.
    b. When rivets are used, adequate spacer or other satisfactory means to prevent excessive tightening of the frame to the plastic should be provided.
    c. When rivets or nuts and bolts are used, slotted holes are not recommended.
    d. When nuts and bolts are used, the plastic should be installed cold and each nut tightened to a firm fit before the plastic warms up.

30. When installing transparent plastic enclosures which are retained by bolts extending through the plastic material and elastic stop nuts, the stop nuts should be

    a. Tightened to a firm fit plus one full turn.
    b. Tightened sufficiently to make a waterproof seal.
    c. Tightened to a firm fit then backed off one full turn.
    d. Tightened to a firm fit.

31. If an aircraft's transparent plastic enclosures exhibit fine cracks which may extend in a network over or under the surface or through the plastic, the plastic is said to be

    a. Creeping.
    b. Fatiguing.
    c. Stretching.
    d. Crazing.

32. Which of the following is an identifying characteristic of acrylic plastics?

    a. When heated or burned, has a very repugnant odor.
    b. Zinc chloride will have no effect.
    c. Has a yellowish tint when viewed from the edge.
    d. Acetone will soften plastic, but will not change its color.

33. Which statement is true regarding a cantilever wing?

    a. It employs lift wires instead of lift struts.
    b. It has nonadjustable lift struts.
    c. No external bracing is needed.
    d. It requires only one lift strut on each side.

COURSE TEST

34. If no scratches are visible after transparent plastic enclosure materials have been cleaned, their surfaces should be

    a. Buffed with a clean cloth dipped in a mixture of turpentine and chalk.
    b. Polished with an automobile cleanser applied with a damp cloth.
    c. Buffed with a clean, soft, dry cloth.
    d. Covered with a thin coat of wax.

35. What is the most common method of cementing transparent plastics?

    a. The heat method.
    b. The soak method.
    c. The splice method.
    d. The bevel method.

36. Which of the following conditions will determine acceptance of wood with mineral streaks?

    a. Careful inspection fails to reveal any decay.
    b. They do not cause grain divergence.
    c. They produce only a small effect on grain direction.
    d. Local irregularities do not exceed limitations specified for spiral and diagonal grain.

37. Which of the following is an identifying characteristic of cellulose acetate plastics?

    a. Burns with a steady, clear flame.
    b. Rub and blow acetone; it will turn blue.
    c. When heated or burned, has a very pleasant odor.
    d. Zinc chloride will turn the plastic milky.

38. When holes are drilled completely through Plexiglas, a

    a. Standard twist drill may be used.
    b. Combination drill should be used.
    c. Special modified twist drill should be used.
    d. Wood drill may be used.

39. Monocoque fuselages derive their principal strength from

    a. Bulkheads and longerons.
    b. Longerons and formers.
    c. The actual covering, metal, or plywood.
    d. Metal stringers.

COURSE TEST

40. When patching a plywood skin, abrupt changes in cross-sectional areas which will develop dangerous stress concentration should be avoided by using

   a. Circular or elliptical patches.
   b. Rectangular patches.
   c. Square patches.
   d. Doublers with any desired shaped patches.

41. The strength of a glue joint must be equal to

   a. 75 percent of the wood strength.
   b. The strength of the wood.
   c. Twice the strength of the wood in tension.
   d. 50 percent of the wood strength.

42. Semi-monocoque fuselages derive their principal strength from

   a. The actual covering, metal or plywood.
   b. Bulkheads and formers.
   c. Metal stringers.
   d. Bulkheads and longerons.

43. Elongated bolt holes in a wood spar may be repaired by

   a. Splicing in a new section of spar and drilling new holes.
   b. Attaching reinforcement plates of 1/4 the spar width.
   c. Reaming the holes and inserting bushings whose wall thickness is 1/4 the original bolt diameter and whose length is 1/32 less than the spar width.
   d. Reaming and inserting the next standard size larger bolt.

44. The I-beam wooden spar is routed to

   a. Improve shape.
   b. Increase strength.
   c. Remove imperfections.
   d. Reduce weight.

45. In cases of elongated bolt holes in a wood spar or cracks in the vicinity of bolt holes,

   a. It is permissible to plug the hole with hardwood and redrill.
   b. A plug should be inserted in the hole and a reinforcement plate added.
   c. The spar may be reinforced by using birch reinforcing plates.
   d. A new section of spar should be spliced in or the spar replaced entirely.

COURSE TEST

46. Longitudinal (fore and aft) structural members of a semi-monocoque fuselage are called

    a. Spars and ribs.
    b. Longerons and stringers.
    c. Bulkheads and rings.
    d. Ribs and formers.

47. Laminated wood spars may be substituted for solid rectangular wood spars

    a. Only in certain instances where the primary load is shared by one or more other original structural member.
    b. Only if the strength deficiency is allowed for by an increase in dimension.
    c. If the same quality wood is used in both.
    d. Only upon specific approval by the manufacturer or the FAA.

48. A faint line running across the grain of a wood spar generally indicates

    a. Compression failure.
    b. Fungus growth.
    c. Shear failure.
    d. Decay.

49. The cantilever wing uses

    a. External wood bracing.
    b. Ribs as the principal structural members.
    c. No external bracing.
    d. The skin to carry most of the load to the wing butt.

50. Laminated wood is often used in the construction of highly stressed aircraft components. This wood can be identified by its

    a. Increased resistance to deflection.
    b. Parallel grain construction.
    c. Similarity to standard plywood construction.
    d. Alternate perpendicular ply construction.

51. Which of the following types of patch is preferred for repairing stressed plywood skin?

    a. Surface patch.
    b. Splayed patch.
    c. Plug patch.
    d. Scarf patch.

52. The strength of a well-designed and properly prepared wood splice joint is provided by the

    a. Bearing surface of the wood fibers.
    b. Doubler.
    c. Glue.
    d. Reinforcement plates.

53. Compression failures in wood structures are characterized by buckling of the fibers that appear as streaks on the surface

    a. At right angles to the growth rings.
    b. Only in the heart wood.
    c. Only in the spring wood or summer wood.
    d. At right angles to the grain.

54. Three forms of decay in wood structures are

    a. Mineral streaks, compression wood, and dote.
    b. Compression wood, dote, and red heart.
    c. Dote, red heart, and purple heart.
    d. Spring wood, summer wood, and dote.

NAME ______________________________

DATE ______________________________

AIRFRAME
A201 AIRFRAME STRUCTURES AND NON-METALLIC STRUCTURAL REPAIR
ANSWERS TO COURSE TEST

	a	b	c	d		a	b	c	d		a	b	c	d
1.	○	○	○	●	16.	●	○	○	○	31.	○	○	○	●
2.	●	○	○	○	17.	●	○	○	○	32.	○	●	○	○
3.	○	●	○	○	18.	○	●	○	○	33.	○	○	●	○
4.	○	●	○	○	19.	○	○	●	○	34.	○	○	○	●
5.	○	○	○	●	20.	○	○	○	●	35.	○	●	○	○
6.	○	○	●	○	21.	●	○	○	○	36.	●	○	○	○
7.	○	●	○	○	22.	○	○	●	○	37.	○	○	○	●
8.	○	●	○	○	23.	○	○	●	○	38.	○	○	●	○
9.	○	○	○	●	24.	○	○	●	○	39.	○	○	●	○
10.	●	○	○	○	25.	●	○	○	○	40.	●	○	○	○
11.	○	○	○	●	26.	○	●	○	○	41.	○	●	○	○
12.	●	○	○	○	27.	●	○	○	○	42.	○	○	○	●
13.	●	○	○	○	28.	●	○	○	○	43.	●	○	○	○
14.	○	●	○	○	29.	○	●	○	○	44.	○	○	○	●
15.	○	○	●	○	30.	○	○	●	○	45.	○	○	○	●

ANSWERS TO COURSE TEST

	a	b	c	d
46.	○	●	○	○
47.	○	○	●	○
48.	●	○	○	○
49.	○	○	●	○
50.	○	●	○	○
51.	○	○	○	●
52.	○	○	●	○
53.	○	○	○	●
54.	○	○	●	○